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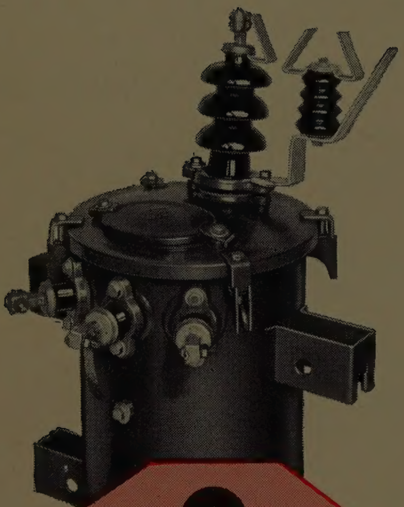

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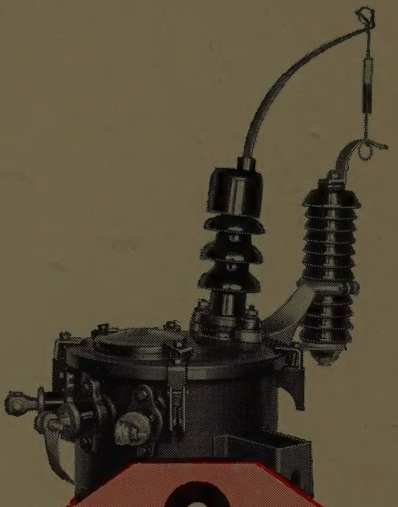

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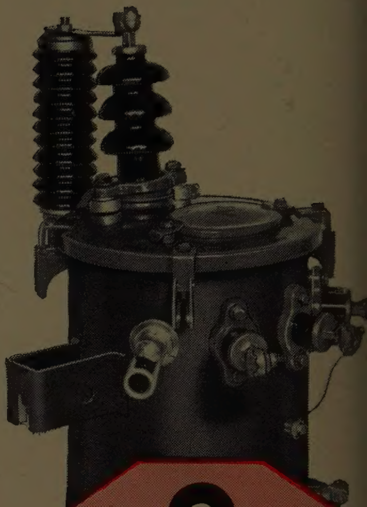

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FEBRUARY

1951

The Cover: The new Ridgeland Station of the Commonwealth Edison Company of Chicago, Ill., is shown. The first 150,000-kw unit was placed in service October 29, 1950; the second 150,000-kw unit now is under construction and will be in service in 1951; two more units are to be built and service is scheduled for 1953. An ultimate capacity of 600,000 kw is planned (see story on page 106). Commonwealth Edison Company photo

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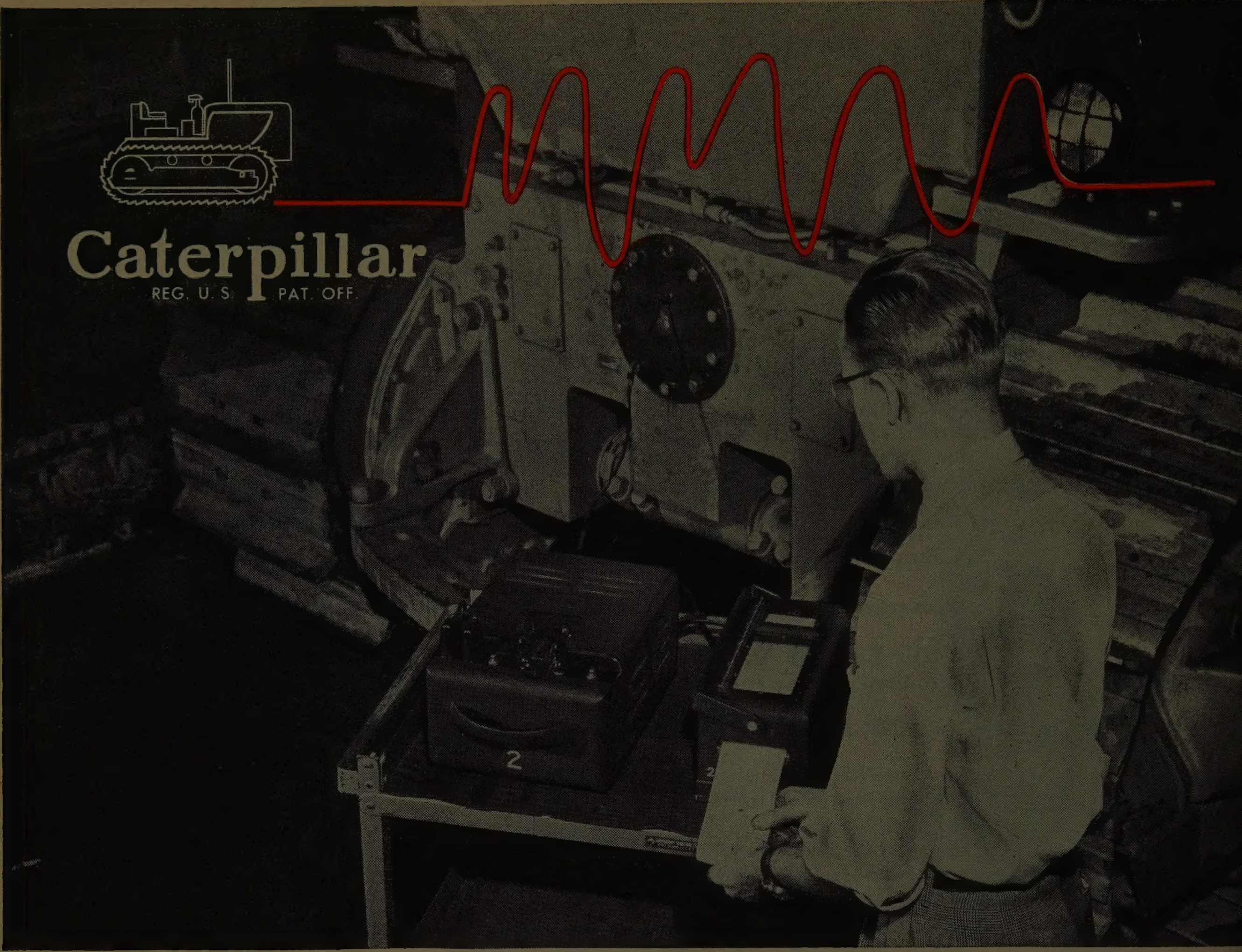

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HIGHLIGHTS.........

Continuing Technical Leadership. Our country needs technically trained young men, yet by 1954 there will be only 15,000 engineering graduates, says AIEE President LeClair. We cannot afford even for a single year to stop the flow of young men from high school into engineering training (*pages 95–96*).

The Critical Shortage of Engineers. The minimum annual need of engineering graduates is 30,000, says S. C. Hollister, Dean, College of Engineering, Cornell University. How do we obtain this number when there are not enough freshmen enrolled and when those in college are subject to the draft? The situation is very serious, and Dean Hollister discusses many aspects of the problem (*pages 97–99*).

Electrical Safety in Laboratories. In order to make engineers more aware of hazards inherent in laboratory work, a discussion of these hazards is presented this month. Suggestions are made to make laboratory equipment safer and to educate laboratory workers to be conscious of the care which must be exercised (*pages 99–103*).

Principles of Professional Conduct. The Statement of Principles of Professional Conduct of the AIEE gives the canons of ethics for engineers, the code of business practice, the use of membership designations and Institute insignia, and the history of the canons and code (*pages 171–73*).

Chicago's New Ridgeland Station. Placed in service October 29, 1950, was the first of four 150,000-kw generating units of the Ridgeland Station of the Commonwealth Edison Company. Work was started on this station in August 1947, and the plant is scheduled to reach its ultimate capacity in 1953 (*pages 106–10*).

Obtaining Registration As a Professional Engineer. This article reviews registration laws and requirements and the advantages to the engineer of being registered. The author also includes a list of national registration boards and boards of examiners (*pages 113–15*).

Test of 220-Kv Circuit Breakers. By modifying equipment and circuits of a 220-kv line, tests have been made in Sweden to obtain data which may be applied to the new 380-kv transmission system. The tests were carried out to investigate the interruption of line-charging current by means of high-speed air-blast circuit breakers (*pages 118–24*).

Information Theory Applied to System Design. The information theory as it may be applied to the design of a communication system is discussed this month by W. G. Tuller of Melpar, Inc. By the use of the information theory in this type of analysis, the effect of necessary deviations from the ideal in bandwidth, power, and speed may be evaluated (*pages 124–26*).

Local Wire Television Networks. Newly developed low-loss shielded video cable pairs have been used to form a local video distribution system. It provides equalization for the cable loss, amplification of the signal, and suppression of high-frequency noise (*pages 130–35*).

Ice Testing of Outdoor Switches. The testing of an outdoor switch under artificial icing conditions is presented by J. B. Owens of the Westinghouse Electric Corporation. Design features of a switch which can be operated under such conditions are described (*pages 139–42*).

A Simple Magnetic Modulator. The design of a magnetic modulator to furnish a constant-phase a-c signal from a d-c signal which does not go over 100 millivolts at 1,000 ohms is discussed. To obtain a sinusoidal signal the equipment had to be designed to operate over a small part of the magnetization curve (*pages 144–47*).

Insulation Resistance on Energized Systems. The insulation of electric systems of ships tends to deteriorate rapidly, and it is desirable to measure the resistance of the system quickly and accurately without de-energizing the system. In order to do this with a single reading, a new instrument has been developed for use on either d-c or a-c systems (*pages 150–54*).

Totally Enclosed Motors. A study of the use of totally enclosed auxiliary drive motors has been made by engineers of the Consolidated Edison Company of New York, Inc., to determine the performance and cost of operation of these machines. The use of this type of motor has cut down outages considerably, and maintenance cost has been reduced (*pages 155–59*).

1950 Engineering Developments. In the section on Insulated Conductors (*EE, Jan '51, pp 6–7*) the conductor size of the 69-kv oil-filled segment cable, shown on page 7, should be 2,750,000 circular mils. The last sentence of the paragraph under the photograph should have referred to the conventional concentric stranded type of hollow core oil-filled cable instead of the pipe type of construction.

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions.*

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Feb '50, p 46A	Winter General
Jul '50, p 30A	Winter General North Eastern District Great Lakes District Summer and Pacific General
Nov '50, p 43A	Middle Eastern District Fall General

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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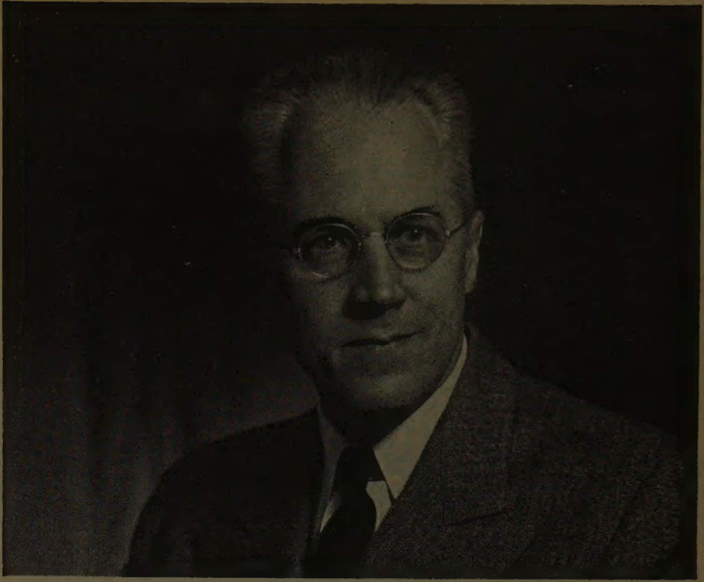

T. G. LeCLAIR
PRESIDENT AIEE

By 1954 there will be only 15,000 engineering graduates. President LeClair discusses the reasons for this trend of fewer men entering the engineering profession, and suggests four thoughts for consideration by members.

ENGINEERING was used for military purposes in early Biblical times, but it is only within roughly the last 100 years that it has been used materially or civilian purposes. In the last 30 years, the engineering rofession has become a rominent segment of the opulation. The engineers re looked to for leadership ot only in war time but for echnical progress in developng the tools for mass producion and for the comforts of ving. Do we realize the rofession has also acquired responsibility to continue this leadership in the future? f so, we should look carefully at the recent trend in the umber of men entering engineering colleges.

In 1940, approximately 1 in 40 of the high school raduates entered engineering college. By 1947, due to he wartime technical progress and to the enthusiasm roduced by the returning servicemen, the entering nrollment increased to about 1 in 20. The sharp increase n the total enrollment in engineering colleges is shown n Table I which shows that the number of first degrees ranted rose from 11,000 in 1939–40 to approximately 8,000 in 1949–50.

Apparently, this sharp increase in engineering enrollment and in new graduates started a rumor or fear that here would soon be a surplus of engineers. Many of us id not realize the startling impact of this rumor. Now e learn that the number of high school graduates entering ngineering college in 1950 has dropped to about 1 in 50.

The word "rumor" is used advisedly because apparently he surplus did not materialize and practically all of the 949–50 graduates were absorbed promptly in jobs to their king. The absorption of this larger number of graduates ithin a very few months is strong evidence that industry will continue to require a large number of engineers in the future for continuing technical progress. A drop in the number of new enrollments or of graduates for a single year need not be an alarming symptom, but a continuation of this trend could have a serious effect upon the country's future. It is the young engineers upon whom industry depends for the new ideas and for the carrying out of the detailed planning which is necessary to technical progress.

With the current enrollment of engineering students, the prospects for engineering graduates, as estimated by the American Society for Engineering Education, are as follows (first degrees from Engineers' Council for Professional Development accredited curricula colleges only)

1951	33,000
1952	22,000
1953	18,000
1954	15,000

What is the meaning of this trend of fewer men entering the engineering profession? Is it an anticipated lack of opportunity? Is it a relatively low rate of pay in the profession? Is it lack of available material? Recent experience has shown that there is no lack of opportunity when four times the normal prewar "crop" of graduates can be absorbed so readily. It is also interesting that this large number of graduates was absorbed without any drop in the rates of pay offered to new graduates. It does not seem reasonable that something strange is happening to the population, whereby there should be any decrease in the proportion of young men who have the necessary attributes and abilities to be trained for the engineering profession.

May I suggest the following thoughts for you members who constitute the leadership of the profession and who

---

bstract of an address presented at the Winter General Meeting, New York, N. Y., nuary 22–26, 1951, during the General Session on January 22.

. G. LeClair is chief electrical engineer, Commonwealth Edison Company, Chicago, Ill.

Table I. Engineering Undergraduate Enrollment

(Institutions in United States Only)

Year	Freshman	Sophomore	Junior	Senior	Fifth Year	Part-Time and Evening	Total	Number of First Degrees
1940	33,175	24,242	20,120	16,310	985	13,459	108,291	11,358 (1939–40)
1947	57,507	71,615	48,227	32,369	1,846	18,616	230,180	18,592 (1946–47)
1948	47,672	52,949	59,945	45,695	1,924	17,932	226,117	27,460 (1947–48)
1949	36,508	35,648	41,695	50,991	2,326	13,478	180,646	41,793 (1948–49)
1950	29,394	27,242	30,957	37,707	3,150	14,504	142,954	48,160 (1949–50)
1951								33,000 (Estimated)

have the best interests of the profession and public at heart:

1. Engineering is a specialized field which requires an analytical mind and other special abilities for success and progress. Therefore, the profession will not profit if large numbers of unqualified men are drawn to it solely because a temporary shortage creates unusual opportunities in the field. On the other hand, the profession and the public can ill afford to put any limit on the number of qualified young men being admitted in an attempt to make the profession exclusive.
2. The engineering approach can be used in so many ways in every part of industry that no qualified young engineer need fear that there is a lack of future opportunity for advancement.
3. Whether we are presently to be engaged in an economy which is largely military, largely civilian, or any combination thereof, there is a steadily increasing need for well-trained men in engineering.
4. Even with urgent military needs, it is important that the flow of young men into technical training be continued. We do not know whether the emergency may be long or short, but is it not reasonable that qualified young men can be of greater service training in their specialty than training for general service, whether or not they are under military control?

Each of us is an emissary of the profession in our informal discussions with relatives and friends, high school instructors and principals, and in vocational guidance interviews. Therefore, let us not be swayed by any false rumors that there is a surplus of engineers from some of the figures which were published six months to two years ago. Let us also not go to the other extreme and think that because of the trend to smaller numbers of engineering students, there will be such a shortage of new blood that engineering faces a gold rush for unqualified men.

In discussing future prospects with students and their advisors, can we concentrate on the fundamental that engineering presents a remarkable opportunity for a full and serviceable life in a profession which occupies a growing importance in the economy of the country? No person can accurately predict the exact number of jobs to be available in a particular field in a particular year. We can truthfully say that any qualified young man may enter an engineering college without any fear that the profession is approaching a saturation point.

The country needs technically trained young men. We cannot afford even for a single year to stop the flow of young men from high school into engineering training. Whether their status in training is to be military or civilian is less important than the fact that they certainly will be needed as soon as they are trained. There is not only an opportunity for these young men in the field, but a necessity on the part of the country to preserve its leadership.

High-Current Generator Shipped to India for Lightning Research

Modern research developments and design techniques have been incorporated in a new high-current impulse generator shipped to the Indian Institute of Science, Bangalore, India, by the General Electric Company's Transformer and Allied Product Divisions, Pittsfield, Mass.

This new research aid will be used to extend investigations of heavy surge currents and their effects on electric apparatus. The generator will simulate the currents of natural lightning discharges. Rated at 100,000 volts, 6 microfarads, 150,000 amperes, the high-current impulse generator consists of 48 capacitors rated 50 kv, 0.5 microfarad. These capacitors are mounted on shelves arrayed in an open square to facilitate a direct discharge into the test specimen which will be placed in the test cabinet located in the center. This arrangement also facilitates observation of the specimen while it is undergoing tests.

The measurement of the high currents this machine is capable of generating requires special high surge current shunts arranged in a concentric design, which are accurate to within 1 per cent up to 400 kilocycles. All supplementary equipment necessary for the correct operation of the impulse generator was also shipped.

The Critical Shortage of Engineers

S. C. HOLLISTER

UR COUNTRY is once again obliged to arm in an effort to preserve peace, and to prepare for attack if it should come. No thinking person fails grasp the fact that we are greatly outnumbered and that ir chances of survival are dependent upon our ability outdesign, outdevelop, outproduce, and outperform r enemies. At the same time that we are preparing for ssible large-scale war, we must maintain, on a more icient basis than ever before, our civilian functions. oreover, we must prepare for eventual attack on our ies and on our industries and for the invasion of our meland.

World War II brought to public attention the extent of e contribution to the war effort of the scientists and gineers. We could not ve fought, much less won, at war without the vast uipment planned, devel- ed, built, and operated by gineers. Not only have the gineers provided the untry with the labor-saving vices, the means of trans- rtation, communication, oduction, and distribution peacetime, but they have so provided the special ver- ns of all these services for ar. The engineers design, develop, produce, and operate e ships, the planes, the guns, missiles, rockets, and am- unition, the tanks and armored vehicles, the radio, radar, nar, loran, and other devices of communication and tection, the vast transportation facilities needed in arfare. They are clearly indispensible.

Unless drastic action is taken to increase the supply of engineering freshmen and to continue the training programs of World War II, there will be a cumulative shortage of over 40,000 engineering graduates by 1954. On the basis of Dean Hollister's report, the Engineering Manpower Commission of the Engineers Joint Council recommended a 4-point program to the National Security Resources Board (see news item on page 179).

But we are short of engineers. As we advance in the ar preparations the shortage will be greater. As one ntemplates the dependence upon engineers in the task fore us, the seriousness of a shortage in this part of our anpower becomes evident. It comes about because ere has been a falling off in enrollments in engineering lleges, largely due to a widely and erroneously held lief that engineers were in oversupply. The shortage ll deepen if engineers are drafted or called up as re- rvists and used in positions for which engineering training d experience are not mandatory.

Figure 1 presents the essential factors in the outlook for pply of engineering graduates. The lower curve shows e annual output of the engineering colleges of the country r the academic years 1935–36 to 1950–51. It shows that from 1942 through 1945 the country, through its mistaken manpower policy, all but stopped the operation of engineering education. That is the reason why industry today is not successful in finding critically needed engineers with five to ten years' experience. They were not produced at the rate they should have been.

Beyond 1950 a dotted line shows the estimated number of graduates to be expected if the schools operated without any withdrawals by Selective Service. It represents the most optimistic production possible, at least until 1954, since all classes graduating up to that year are already enrolled in the colleges.

Since the number of graduates depends upon the number entering the colleges, the curve of freshmen is shown. Again is evident the low enrollment of freshmen of the war years, many of whom were taken out of college for military service. Following the war, the veteran benefits program brought the unprecedented number of 91,000 freshmen into the colleges in the fall of 1946. These did not come direct from the high school graduations in that year, but represented an accumulation of high school graduates who, for several years, had not been permitted because of the draft to proceed with college training. Since 1946 the numbers of freshmen have fallen rapidly until in 1950 there are enrolled about 30,000.

Beyond 1950 there is shown a dotted line indicating estimated freshman enrollment. This estimate was made before the Korean War, and was based on normal peacetime expectancies. It is seen that the actual enrollment for 1950 did not reach the estimate, due largely to widespread rumor that the engineering field was oversupplied.

The present situation already shows tightness in all fields, and critical shortages in many. Industry has absorbed the last two graduating classes of nearly 50,000 each and is hotly contesting for the 30,000 that will graduate in 1951. Many of the graduates are in Reserve Officers Training Corps programs and may thus go direct to military service. A large number have draft postponements and will be subject to call in June, if not before. Still others are veterans.

On August 3, 1950, the Secretary of Labor placed all branches of engineering on the list of critical occupations. In all the major branches, the shortage of engineers is becoming progressively more critical, especially in aeronautical, chemical, electrical, and mechanical manu-

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ll text of a report presented to the Engineering Manpower Commission of the Engi- rs Joint Council on December 18, 1950.

C. **Hollister** is Dean, College of Engineering, Cornell University, Ithaca, N. Y.

facturing fields. Men with a few years of experience are almost unobtainable.

In normal peacetime it is generally accepted that at least 20,000 graduates are required annually. In the present situation it should be recalled that industry has absorbed 50,000 engineers in each of the last two years; but some of these certainly take the place of those that could not be hired in war years because in those years they were being produced only in small numbers. Industry, however, does not have all it needs; and the military requirements have not as yet been taken. Thus it appears that the minimum annual need is not less than 30,000 engineering graduates with use for many more if they should be available.

How do we obtain not less than 30,000 graduates yearly? First of all, to do so requires an annual input of 60,000 freshmen. This is about double the number entering engineering schools this year. How may twice as many high school graduates be attracted to engineering schools? Are there that many among the high school graduates who have an interest in engineering and who, at the same time, have the necessary aptitude and abilities?

The numbers of male and female high school graduates anticipated are shown at the top of Figure 1. It appears that between 1950 and 1958 there will be a 10-per cent dip in the numbers graduating so that the range is between 1,250,000 and 1,130,000. We clearly cannot rely, therefore, upon an increase in output of the high schools to solve the problem.

Except for the war and immediate postwar years, which were abnormal, the numbers entering engineering schools since 1935 range from 2.7 to 3.1 per cent of the total high school graduating classes. On the basis of an average high school output of 1,200,000 boys and girls, 5 per cent would be required to produce 60,000 engineering freshmen. This is about 10 per cent of the boys graduating from high school. There is some doubt whether the combined factors of aptitude, ability, and interest would be found in so high a percentage. It seems possible that the 60,000 freshmen shown as needed on the chart may be at or above the available number that can be expected to enter engineering. This brings home the fact that there is not, and there cannot be developed, an inexhaustible supply of engineering talent, but instead the supply is sharply limited.

Nevertheless, it is essential that all available avenues of information be used to acquaint the high school principals, high school guidance counselors, and the high school students themselves with the shortage and consequent need of engineers in all categories. It is vital to our security and welfare that such important information reach these persons.

What is significant to industry in the picture here se forth? It means that there will not be young replacements for engineering jobs vacated by the calling of reservists or of draftees. There will be only a partial supply of young engineers for new jobs as conversion, retooling, and war production may require. Intercompany pirating will only add to the difficulties of staffing. Robbing the colleges of faculty members for industrial jobs will surely dry up the supply and reduce the quality of training given by the colleges.

It will be essential for industry to re-examine the functions of the engineering personnel and to make certain that each engineer is being used in the most effective manner possible. No engineer should be used in positions others can occupy as well. Supporting personnel requiring less training and experience, should be used to spread a far as possible the effectiveness of each engineer. Even competent supporting personnel will be tight. It will be necessary t begin in-service training of such personnel and to engage women as far as possible. The training programs o the last war will need to be re-established

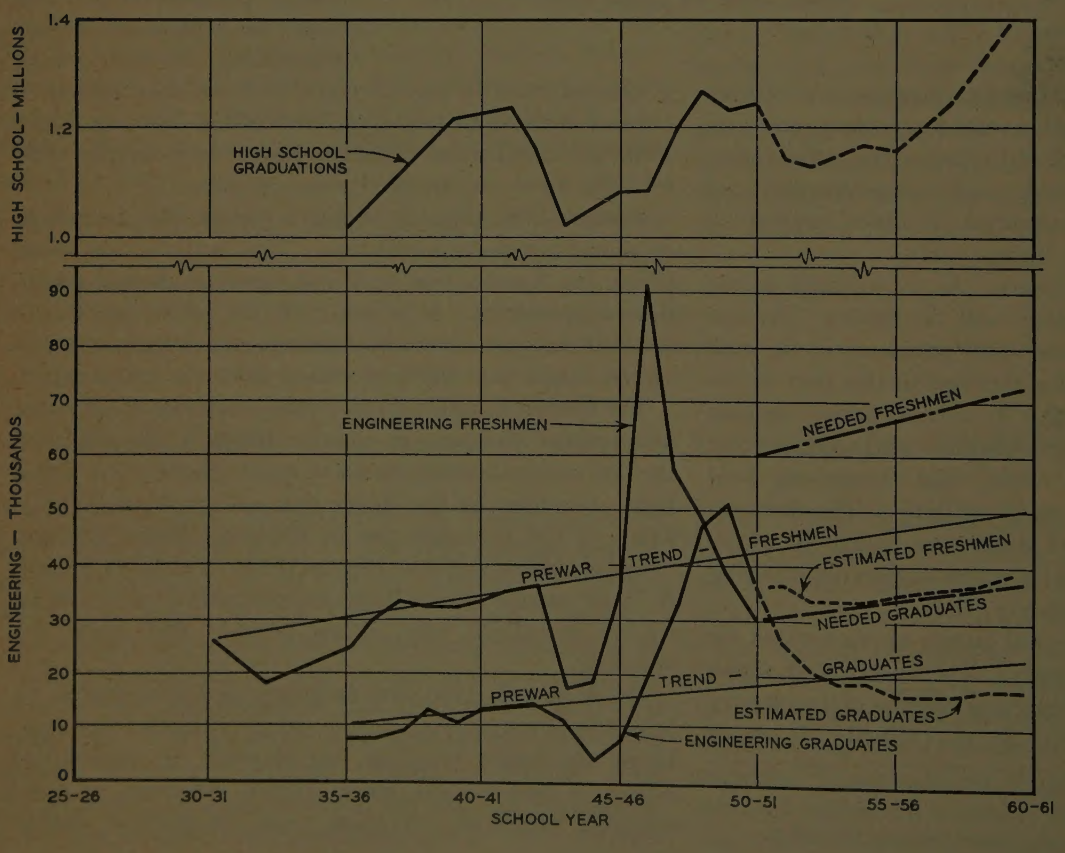

Figure 1. Outlook fo the supply of engineering graduates. Actua and estimated enrolment by the Unite States Office of Education; needed students e timated by Dean Holliste

None of these steps can be put off. The organization of ndustries must be streamlined now.

Government agencies, including the armed forces, must ake cognizance of the situation. Plans must be developed whereby the engineering manpower needs of the services and of industry may be so co-ordinated that both will be ppropriately served from the limited supply. Industry has the job of supporting the military. To assume that he military needs are paramount or exclusive would be a orm of national suicide. A careful planning for utilization of men with engineering training and experience only in categories where such training and experience are mandaory should be undertaken; although such probably cannot be wholly achieved, it is in the interest of the total effort that such an objective be approached as nearly as possible. Sound policies relating to deferment and the calling of reservists must be promulgated with the objective of maintaining a balanced utilization.

It is reported in the technical press that the Russians, in their current 5-year plan, are scheduled to have produced 150,000 engineering graduates by the end of 1950. This matches our own output for the same period. During the next five years, however, we will drop by one-third unless drastic action is taken to increase the supply of engineering freshmen and to continue the training operation in full force.

Obtaining Safety in Experimental Electrical Laboratories

C. F. DALZIEL
MEMBER AIEE

Although the potential engineer often gets his first practical knowledge of electricity in a school laboratory, few safety precautions are taught in these laboratories. Suggestions are given here for increasing safety awareness and decreasing hazards in experimental electrical laboratories of schools and industrial plants.

THE PRESENCE of electrical hazards and the conditions inherent in the operation of experimental laboratories suggest the desirability of developing policies and procedures aimed at raising the level of safety n industrial and educational laboratories. Experimental aboratories may be divided into three general types, ndustrial, research, and instructional. Instructional aboratories may be vocational, or junior or senior college level; they are places where large numbers of students first become acquainted with laboratory techniques. Research laboratories may be situated in educational, commercial, or other organizations, but in any case can be egarded as those places where advanced instruction is carried on or where investigations of a highly technical nature are conducted, such as nvestigations of high-voltage or high-frequency phenomena or other work utilizing highly specialized apparatus. ndustrial laboratories may be considered as including a wide range of facilities where operators may be semikilled and where testing is usually of more or less routine nature.

Prevention of accidents requires a great deal more than mere accumulation of knowledge and assignment of accident prevention responsibilities. Raising the level of safety n experimental laboratories requires the active co-operaion of many individuals. In educational laboratories, for instance, the passive attitude of many professors to safety matters may be reflected in the attitude of the teaching assistant and thus passed on to the students. It may be taken for granted that there is a difference in the practicability of prescribed safety requirements for commercial and educational laboratories, but this does not explain why regulatory bodies so often refrain from assisting educational institutions in eliminating hazardous conditions and in promoting better practices. The breach in safety consciousness between the practicing engineer and the manufacturers of commercial equipment on the one hand and the educator and the manufacturer of experimental laboratory apparatus and instruments on the other must be bridged. Raising the level of safety in experimental laboratories and the anticipated future reduction of industrial accidents requires the active support of several branches of the profession.

The primary objective of safe procedures and practices is to exterminate the causes of accidents. The causes are

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Full text of a conference paper presented at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. Fifth in a series of articles on safety. See "Perception of Electric Currents," C. F. Dalziel, T. H. Mansfield (*EE Sep '50, pp 794–800*), "108 Are Missing," E. G. Hunt (*EE Oct '50, pp 919–21*), "Safety Testing of Electronic Equipment," O. G. Wedekind (*EE Nov '50 pp 997–1000*), "Electrical Work Injuries in California Industries from 1940 to 1949," E. E. Carlton (*EE Dec '50 pp 1076–7*).

C. F. Dalziel is professor of electrical engineering, University of California, Berkeley, Calif.

The writer wishes to acknowledge and thank his associates for their many helpful suggestions and comments in the preparation of this article.

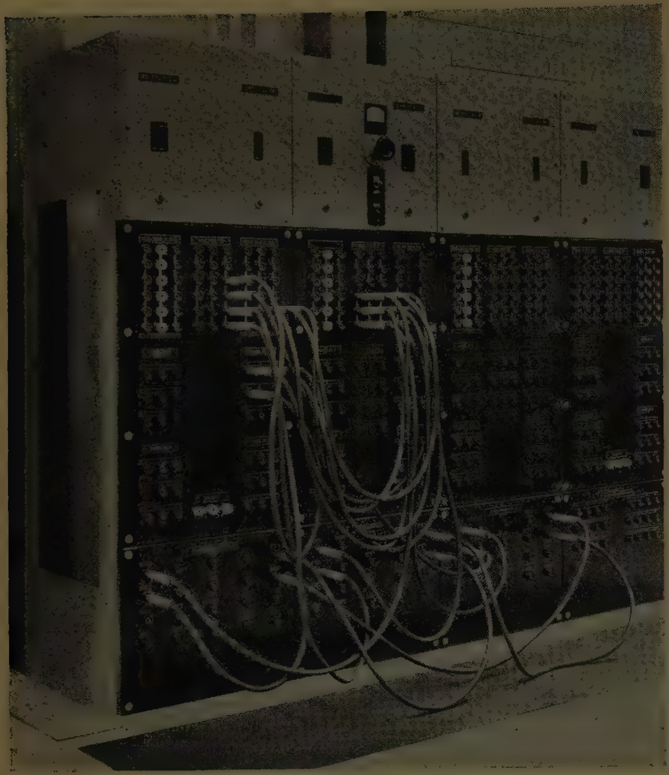


Figure 1. This laboratory switchboard is equipped with plastic-encased air circuit breakers. The front of the switchboard is made of ebony asbestos and the energized part of the receptacle is recessed one-fourth inch

of three types. The poorly trained man may be injured because he is completely unaware of the existence of a given hazard. The advanced student may become involved in an accident because he is not alert to a known hazard. Any worker may suffer serious injury because he disregards an obvious hazard. Whatever the cause, the laboratory supervisor assumes grave responsibilities for the safety of his personnel, and in case of serious injury he may find himself suffering remorse and loss of professional prestige, or, if his neglect is gross and obvious, criminal charges and loss of his job.

For purposes of this discussion it may be assumed that all permanent equipment in a laboratory has been installed according to prescribed safety standards, and that the areas of hazard are associated with laboratory switchboards and portable or semipermanent installations of machines, transformers, switchgear, instruments, and related devices. Such equipment is usually connected with portable leads, and either because of necessity or convenience adjustments or changes in connections are often made when the equipment is energized.

In instructional laboratories one of the difficulties of enforcing safety arises from the fact that in large institutions a laboratory class may consist of 12 to 20 students under the direct supervision of a teaching assistant. Although care is taken to make sure that the supervisor is a man of promise, it is likely that he has had little practical experience and this may be his first experience in assuming authority. The sizable group, limited experience of both students and supervisor, and youth's inherent tendency for horseplay contribute to potential hazards. An essential step in coping with this situation is the scheduling of a regular period at the beginning of the laboratory course for discussion, preferably with demonstrations, covering the operation and adjustment of circuit protective devices, safe laboratory practices, location of first-aid kits and fire extinguishers, effects of electric shock on man, rescue of a victim from the circuit, and approved methods of resuscitation.

In research laboratories hazards due to the higher voltages frequently used are somewhat offset by the smaller group handling equipment and to the greater competence of both researchers and supervisor. Where high-voltage equipment is used (that is, voltages in excess of 600 volts), warning signs, safety-interlocks, and an adequate supply of barrier tape and rubber goods maintained in good condition must be provided. All noncurrent-carrying parts, such as machine frames and instrument transformer secondary circuits, must be effectively grounded. Perhaps the most pressing hazard in such places is the tendency for a researcher to seclude himself and to work alone for hours, often late into the night. No man should be allowed to work on energized high-voltage high-power equipment out of sight of associates. Although it is essential that warning signs be placed at appropriate locations, the use of such warnings must be limited, as there is truth in the old saying "familiarity breeds contempt."

Although a painstaking effort must be made to reduce hazards to as low a level as practicable, acceptable minimum standards must be based upon the conditions existing in the particular laboratory considered. For example, some of the practices which should be prohibited in vocational or junior laboratories might be considered tenable in research laboratories, in which case they should be recognized as a normal risk of the venture. Furthermore, after a definite period of training a young man reaches the status of a properly qualified or authorized person, and the relative hazard of a given situation may change accordingly.

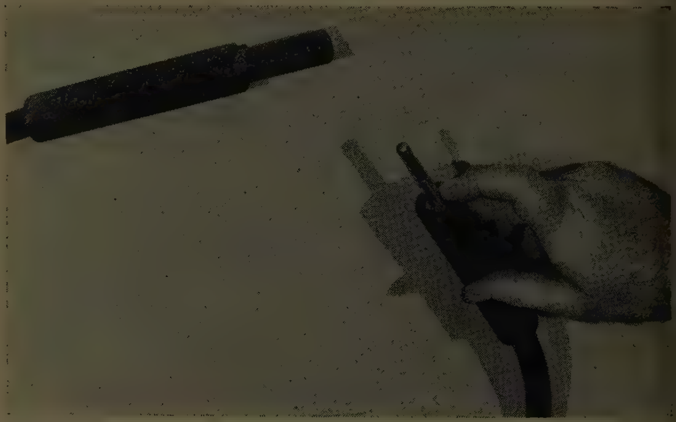
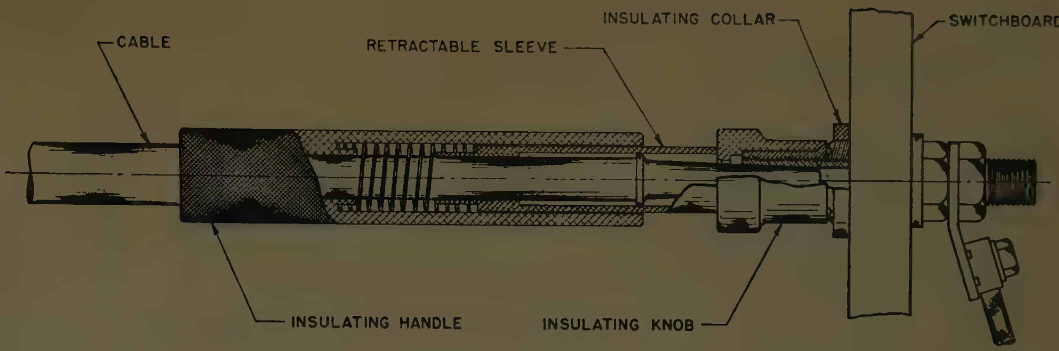


Figure 2. A 100-ampere tapered plug with self-protecting spring-operating insulating sleeve shown in two positions

For economic reasons safety requirements must be kept within reasonable limits and confined to areas where real igure 3. Construction of lf-protecting plug and knob binding post



azards exist. Certainly no effort or expense should be pared in the prevention of accidents, but it is essential that otential hazards be carefully evaluated. Money should ot be spent in areas where the possibility of injury is very emote.

In educational institutions, the prevention of student njury is important, but a greater purpose is to make each tudent safety minded. The most certain road to reduction f industrial accidents is to create safe thinking and working abits during the training of the young engineer. Although reduction of electrical hazards is essential, it would e a grave mistake to eliminate all hazards during the raining period. Such a procedure would inevitably esult in lack of appreciation that industrial hazards exist, nd it would most certainly lead to an unhealthy attitude egarding safety in general. It is important that the oung man, early in his training, be led to recognize the otential hazards of his chosen profession. However, this nportant consideration certainly does not constitute ıstification for the continuation of hazards which can be revented.

The general safety problems in experimental laboratories are illustrated by the procedures in instructional aboratories, where operations include demonstration, esting, and circuit synthesis. Although demonstrations nay be effectively conducted using totally enclosed apparatus, experiments involving testing and synthesis often equire ready access to energized components. Experiments which last only three or four hours may require everal changes in connections and adjustments in addition o measurements at various points, and in many cases hese operations must be made while the apparatus is nergized. Enactment of regulations requiring that all quipment be totally enclosed, or dead-front and dead-back, would result in serious impairment of instruction. Quite aside from the undesirability of impairing instruction, limination of all hazards would fail to develop the student's onviction that electricity is potentially dangerous, and it vould fail to develop proper respect for bare copper. As result, many educators feel that it is essential that the tudent be placed in proximity to low-voltage circuits, usses, contactors, commutators, and the like.

The first requirement in a school laboratory is that all ermanently installed laboratory equipment comply with he electrical safety code of the state. However, it is ifficult, if not impossible, to apply prescribed rules to much f the equipment used in laboratory instruction, so the econd step is to classify hazards and to study of ways and means of reducing them. A classification of hazards in experimental laboratories follows.

1. Electric shock hazard due to casual contact
2. Let-go hazard due to gripping contact
3. Short-circuit hazards
   A. Circuit opening devices—interrupting capacity
   B. Circuit closing devices—trip free action, and sputtering of molten metal
4. Arc hazards
   A. Harmful radiations
   B. High temperature
5. Mechanical hazards
   A. Overspeed
   B. Exposed couplings
   C. Tripping over leads or equipment
   D. Defective tools or equipment, or improper use of them.

These hazards are approached in the following manner: It is concluded that the shock hazard from casual contact with energized parts has to be reduced, and it is also concluded that electric shock hazards cannot be completely eliminated. Means of reducing the hazard are receiving continuous study on an individual item basis, but it is believed that this hazard must be accepted as one of the risks of experimental laboratories.

In contrast, the let-go or freezing hazard due to grasping energized conductors, especially bare terminals, must be eliminated. Insulation of all terminals which might be grasped presents a formidable but not an insurmountable task.

Short-circuit hazards and hazards due to electric arcs must be eliminated as far as practicable. In the control of these hazards a distinction is made between switches which may be closed against short circuits and those which are used to interrupt or by-pass load currents only. The shock hazards from exposed switches designed to interrupt or by-pass normal load currents, such as ammeter cutout switches, knife, dial, or fan switches on rheostats and resistor loading devices, and so forth, are considered one of the normal hazards of laboratory instruction. In contrast, devices which may be closed against short circuits must be given very careful consideration. All open knife switches which might be used for this purpose must be replaced with enclosed externally operable types. Circuit breakers must be trip-free and have adequate interrupting capacity, and the exposed arcing contacts of portable air circuit breakers which are used at eye level or below must be

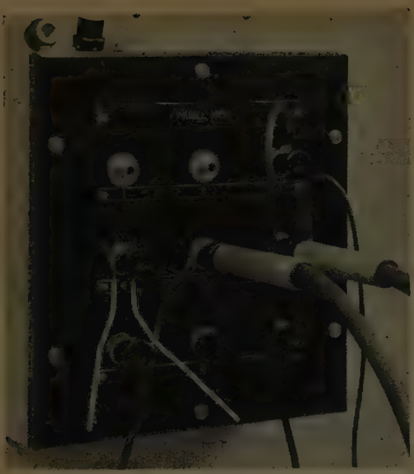


Figure 4. Several different types of leads can be accommodated simultaneously by this type of distribution panel

equipped with hoods or arc chutes to protect against the heat of the arc and harmful radiations. Protection against arc hazards must also be provided on switches used to break highly inductive circuits, including ordinary knife switches often used for field switches.

Overspeed and exposed couplings are generally recognized as the most serious mechanical hazards of rotating electric machinery. All d-c machines should be protected against overspeed by some speed-sensitive device arranged to give positive protection. Couplings should be smooth and free from projecting parts or provided with permanent guards. Many accidents may be prevented by tidy work habits. Good housekeeping, such as keeping unused leads properly racked, tools in their proper places, reporting defective tools or equipment, and arranging equipment and leads to permit access without danger of tripping or stumbling, will eliminate many hazards.

Discussion of a few items will indicate some corrective measures. The senior laboratory switchboard at the University of California is shown in Figure 1. This type of switchboard is familiar as the general layout has been used in experimental laboratories for years; however, one or two points deserve mention. All power sources are protected with plastic-encased air circuit breakers having both thermal and instantaneous magnetic trip mechanisms. The maximum voltage is 480 volts, which is available to the instructor for driving prime movers, but outlet receptacles not in use are blanked out with insulated plugs to prevent accidental use of this voltage. The maximum voltages of the other source outlets are 240 alternating volts and 250 direct volts. Although the switchboard and associated accessories have been approved as complying with the safety requirements of the state, a person could, by deliberate act, contact either the energized part of a receptacle which is recessed one-fourth inch inside its bakelite cup insulator, or he could contact the tip of a 100-ampere plug lead while the other end was energized. This hazard, although considered of minor importance, determined the choice of ebony asbestos rather than steel for the panels containing the receptacles. A rubber mat is provided in front of the switchboard to reduce the proximity of grounded objects which might form a return circuit. Another advantage of insulated panels is that the tip of an energized plug accidentally striking the panel cannot deface the surface due to arcing, except at the holding bolts.

Figure 2 shows the 100-ampere tapered plug with its self-protecting spring-operated insulating sleeve in two extreme positions. Besides almost completely eliminating the freezing hazard, which is the objection to the unprotected plug, the sleeve confines the arc, and its expulsion action materially assists in extinguishing an arc when errors in plugging occur. Construction details of the plug and a knob binding post are shown in Figure 3. Figure 4 shows one of the distribution panels which are spaced at convenient intervals throughout the laboratory. The knob binding posts accommodate several different types of leads simultaneously. During normal conditions ordinary wire is not used for leads in instructional laboratories; however, the grooves in the brass locknuts accommodate wires up to about Number 6 and permit rapid expansion of leads during periods of heavy enrollment, such as occurred shortly after the close of the war. It is often expedient to use rubber-covered wire for leads in research laboratories and for parts of circuits which are to be left wired up for extended periods.

The hazards of control equipment have been given serious attention for several years; see Figure 5 for an example of a typical experiment setup. This equipment may be both live-front and live-back, as many measurements and adjustments are necessary, and some of the work must be done while the apparatus is energized. The devices are used for senior and graduate instruction, and the maximum voltage is 240 alternating volts or 250 direct volts. Although the freezing hazard should not be serious, the shock hazard due to casual contact is high. Either instruction in this important class of equipment should be deleted from the curricula, or the hazards should be recognized and accepted. Because of the increasing importance of this class of apparatus it is desirable that the hazards be accepted as a calculated risk of instruction.

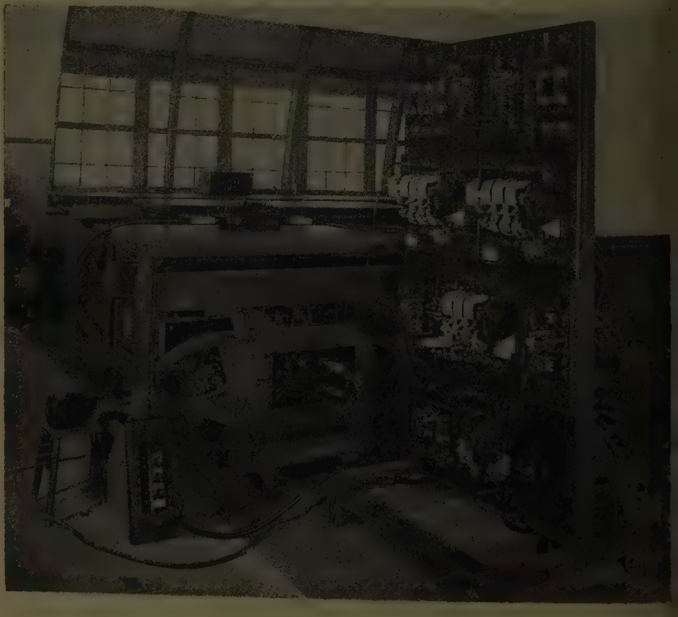


Figure 5. Typical experimental setup which necessarily has many shock hazards

igure 6. Commercial equipment on hich brass binding posts will be replaced by insulated ones

Additional study is being given to the problem of achieving he maximum degree of safety without serious impairment f instructional values.

The foregoing represents but a start on the problem of educing electrical hazards in experimental laboratories. The battle of safety can be won only by co-operative efforts f both users and manufacturers of laboratory apparatus, nstruments, and devices. In Figure 6 are shown recently cquired commercial equipment and instruments equipped with brass binding posts, each of which is to be replaced with insulated binding posts to eliminate as far as practicable the freezing hazard due to accidental contact while energized. Several of the devices have insufficient spacing between energized parts; for example, the terminal board at the extreme right-hand side of the figure was removed from a 480/240-volt motor, and the clearances are not as they should be. As previously stated, corrective measures are being taken on an item-to-item basis, and it is anticipated that the level of safety eventually will be raised to an acceptable standard. It is obvious that much of this needless expense would be eliminated if the manufacturers would incorporate more safety in the design of equipment.

Suggestions for Safety in Laboratories

A person's reputation may be seriously injured if his lack of foresight results in accidents to himself or others.

Haste causes many accidents. Work deliberately and carefully. Check your work as you go along.

Determine positively whether the circuit is "hot" or "cold" before starting work.

Never touch an energized conductor with hands wet with water, perspiration, or chemicals. Never touch an energized conductor when your shoes are wet, when standing in water, on the ground, or on grounded objects.

When working on energized equipment, make a practice of always having an assistant within sight or calling distance.

All power circuits are dangerous. Do not work with voltages higher than 250 volts without taking extra precautions such as the use of rubber gloves, rubber mats, and tools with insulated handles.

When working on electric apparatus which is "hot," use only one hand as far as practicable. Keep the other off of all grounded objects.

Do not start to work on a high-voltage circuit until you have made certain that both the oil circuit breaker and the disconnect switches are open. Place warning signs on all switches that might be used to energize the circuit. Bond all line conductors together and connect them to good grounds placed between possible energy sources and the work location.

Never close a switch slowly or hesitatingly; close it quickly and positively.

Cultivate the habit of turning your face away when opening or closing disconnects or air circuit breakers. Do not avert your face and then grope for the switch or circuit breaker. Use extreme care when breaking highly inductive circuits, as dangerously high voltages are likely to result.

Remember that burns from arcs may be very severe. Guard against arcs as well as high voltage.

Avoid the possibility of exposing your eyes to electric arcs, as they are powerful generators of ultraviolet light, including wave lengths which may cause serious and painful injury to the eyes, even with short exposures.

Be careful to keep watch chains, finger rings, wrist watches, flashlights, metallic and metal-bound measuring rulers, and metallic pencils out of contact with energized circuits.

Do not use wires with poor insulation. Make sure that all splices and connections are securely made and properly insulated.

Do not, under any circumstances, open the secondary of a current transformer while under load. Current transformer secondary circuits must be worked with the secondary short-circuited. (Conversely, potential transformer secondary circuits must be worked open-circuited.)

Be careful to avoid the capacitance effects of transformer cases and other high-voltage apparatus. The frame of every high-voltage machine should be grounded. All conducting objects whose potential is not definitely fixed should be solidly grounded when in the vicinity of high-voltage circuits.

All capacitors should be discharged before working on associated circuits. The charge disappears from capacitors slowly, and interruption of the power supply should be followed by short-circuiting each capacitor before the equipment is considered safe.

Make all connections on the load side first, leaving source connections to the last.

Check all connections before energizing the circuit.

If smoke, fire, or heat give evidence of improper connections or short circuit, open the source switch before attempting to make corrections.

Do not take chances. If you are not certain of the proper procedure ask your superior for proper instructions.

New Low-Voltage Air Circuit Breaker

M. E. HORN
MEMBER AIEE

J. J. MIKOS
MEMBER AIEE

THE GROWTH of modern low-voltage systems has advanced so far that now the low-voltage air circuit breaker must meet requirements which were unheard of ten years ago.

Low-voltage air circuit breakers which can close and latch against fault currents equal to the interrupting rating of the circuit breaker now are required. These circuit breakers also must have a short time rating equal to the interrupting rating. With such characteristics, a circuit breaker may be equipped with tripping devices of either the direct-acting or relay type to provide full selective tripping performance over the complete range of fault current.

Figure 1 illustrates a 3-pole 1,600-ampere 600-volt 60-cycle electrically operated air circuit breaker of 50,000 amperes interrupting rating with direct-acting series overcurrent tripping devices. This "DB Line" of air circuit breakers now includes interrupting ratings of 15,000, 25,000, and 50,000 amperes.

Pole units on this circuit breaker are so designed that the main current-carrying circuit and the secondary arcing circuit are of the blow-on type. The arcing circuit is arranged to enhance the transfer of current from the secondary contact to the primary or uppermost arcing contact. Wide bearings are provided on the contact arms to minimize any sidewise motion caused by interphase attractions and repulsions. Shunts around the hinges eliminate pitting and thus insure a minimum of friction.

Arc extinction is obtained by employing the deionizing principle in an arc chamber consisting of steel plates placed in the arc path perpendicular to the arc and ceramic arc shields in each side of the arc chamber. The steel plates provide the necessary magnetic action to pull the arc into the chamber and to cause the formation of a number of short arcs.

Interruption tests were conducted on this circuit breaker, mounted in a cubicle which had a steel partition $4^{5}/_{8}$ inches above the arc chambers and grounded to the circuit breaker frame and cubicle. Excellent interruptions were obtained with no failures.

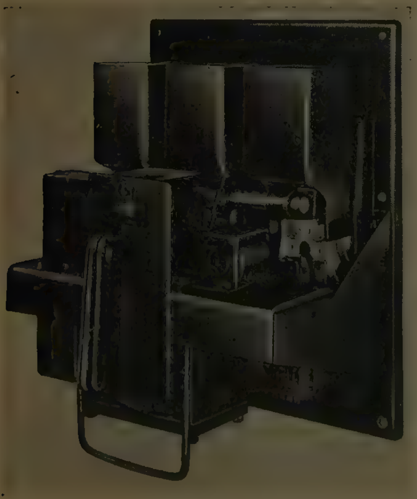


Figure 1. Complete electrically operated circuit breaker in closed position

The conventional insulating base was replaced with a strong steel framework on which individual pole units are mounted. Phase-to-ground insulation is provided by the base mold for the individual pole assemblies.

The circuit breaker frame, vertical panel, and operating mechanism are all at ground potential and thus provide the greatest possible protection to personnel.

An operating mechanism of the trip-free type is used on this circuit breaker. Low mass in the parts results in high-speed tripping. Molded insulating links on each pole unit provide the necessary dielectric between the operating mechanism and current-carrying parts.

High-speed closing is obtained by a d-c closing solenoid with a control relay designed for this particular duty.

Attachments which are self-contained subassemblies such as shunt trip, undervoltage trip with and without time delay, reverse current trip, alarm switch, auxiliary switch, key lock or key interlock, electric lockout, and operation counter do not change the over-all dimensions of the circuit breaker and may be added or changed readily in the field.

Current ratings of the circuit breaker may be changed in the field by replacing the series overcurrent tripping device with a unit of the desired current rating.

The circuit breaker is 19.5 inches wide and may be mounted in tiers of three in a 90-inch switchboard.

Numerous tests have been performed to establish the characteristics of this circuit breaker, such as the interrupting and short-time ratings and closing and tripping speeds. Total closing time is seven cycles, and the total shunt tripping time is 3.4 cycles on a 60-cycle basis.

Through the employment of a unique contact arrangement and a highly discriminating use of space and material, a new low-voltage circuit breaker has been provided which offers greater performance with a reduction in space and weight. The short-time rating has been raised to equal the interrupting rating of 50,000 amperes. The added ability to close and latch on this current permits tripping to be delayed throughout the entire range of fault current which, in turn, facilitates application to obtain the ultimate in selective tripping performance. A high degree of flexibility has been achieved in adapting the circuit breaker for drawout mounting and in adding or changing tripping devices or attachments in the field.

Digest of paper **50-272,** "New Low-Voltage Air Circuit Breaker with 50,000 Amperes Interrupting Capacity at 600 Volts A-C," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

M. E. Horn and J. J. Mikos are with the Westinghouse Electric Corporation, East Pittsburgh, Pa.

Electrical Instrumentation in Medical Research

M. BENJAMIN, JR.
ASSOCIATE AIEE

JOHN HALE

E. L. CARSTENSEN

H. E. TOMPKINS
ASSOCIATE AIEE

RECENTLY there has been a heartening trend in biological research toward closer collaboration be- een the physical and the biological sciences. This ticle is a résumé of a program of this nature being pursued the University of Pennsylvania. In order that such a ogram be well balanced, research, education, and strumentation are all required. These three topics are scussed and new technical developments are described.

Work done in the field of electrocardiography may be ted as one example of research. In explanation of the stribution of potentials on the body surface arising from eart action, an ingenious theory has evolved which is idely accepted. However, some of the fundamental ostulates on which this theory is based are open to question. hief among these is the assumption that for electrocardio- aphic purposes the body behaves as a homogenous olume conductor. Through the years, numerous at- mpts have been made to check this assumption both by easuring directly the resistivities of the various tissues ithin the body and by more indirect means. Investiga- rs have reached widely differing conclusions from their periments so that there is still no definitive answer to the uestion. This past work has been reviewed and evaluated d a series of experiments is under way which, it is hoped, ill throw further light on the subject.

The educational phase of the program has been con- ucted at both the formal and the informal levels. Courses ave been given in Radiologic Physics, Physics Applied to hysical Medicine, Electrical Instrumentation for Research orkers in the Biologic Sciences, Electricity Applied to lectrocardiography, and lectures on the physical aspects f radioactivity applied to medicine. So far, the education f the engineering personnel has been informal in nature, lthough formal courses for physical scientists interested in e biologic sciences are contemplated. It is felt, however, at the informal type of education for both engineers and edical men has been of considerable value, and one of the nportant justifications for the entire collaborative effort es in the opportunity provided for education of this type.

The third phase of the program consists of the develop- ent of instruments for performing physiological measure- ents. The measurement of temperature, blood pressure, nd volume rate of flow of blood are regarded as particu- rly important. Emphasis therefore has been placed upon eveloping instruments to make these measurements.

The thermocouple and the thermistor are the two trans- ucers that seem to lend themselves most readily to this purpose. Of the two, the thermistor is the more sensitive and the necessary associated circuitry for producing a written record is less complex. However, the thermocouple can more easily be made smaller, so that for applications in which size is the limiting factor, a thermocouple is employed.

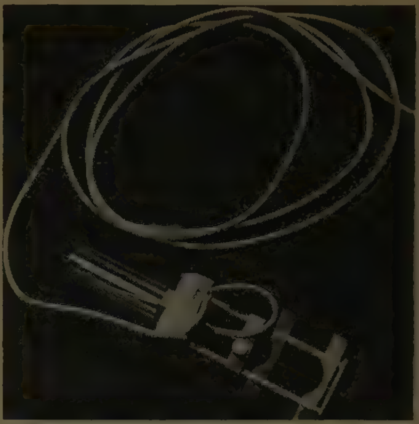


Figure 1. Complete fine wire thermocouple assembly with insertion needle and ice water bath. Hypodermic needle is attached to sliding crossbar. The needle is withdrawn to allow a fine thermocouple to contact surrounding tissue. A double exposure has been made to show the forward and withdrawn positions

Measurement of deep tissue temperature is such an application. To make this measurement, a hypodermic needle with a thermocouple inside it is introduced into the tissue. The hypodermic needle then is withdrawn, leaving the exposed thermocouple in contact with the tissue; see Figure 1. The needle should, of course, be as small as possible to avoid undue tissue damage and pain. For this purpose, a thermocouple of concentric construction was developed in which the outside diameter is approximately 0.0037 inch ($1^1/_2$ times the diameter of a human hair).

For measurement of knee joint and blood temperatures, a bead-shaped Western Electric Company thermistor was placed at the end of a thin polyvinyl chloride tube, having an outside diameter of 0.020 inch. This same style thermistor also has been incorporated in other housings suitable for measuring skin and rectal temperatures.

Detailed information may be obtained concerning the functioning of various parts of the blood circulating system by directly measuring the pressure of the blood within the heart and blood vessels. For this purpose a plastic tube, filled with saline solution, is introduced through a hypodermic needle into the vessel under study. The instrument end of the tube is led to a small chamber, one wall of which is a thin metal membrane. This movable membrane is spaced a short distance from a fixed metal plate, thus forming a capacitance. Small movements of the membrane, with respect to the fixed plate, are measured electrically as changes in this capacitance.

These devices bear witness to a new trend in science: the drawing together of the physical and biological sciences in the hope that mysteries that have thus far withstood the attacks of each science working alone can now be solved by collaborative investigation.

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igest of paper 50-209, "Electrical Instrumentation in Medical Research," recom- ended by the AIEE Committee on Therapeutics and approved by the AIEE Technical ogram Committee for presentation at the AIEE Middle Eastern District Meeting, altimore, Md., October 3–5, 1950. Scheduled for publication in AIEE *Transactions*, lume 69, 1950.

M. Benjamin, Jr., is with the Franklin X-Ray Company, Philadelphia, Pa. **John ale, E. L. Carstensen**, and **H. E. Tompkins** are all with the University of Pennsylvania, iladelphia, Pa.

Chicago's New Ridgeland Station

D. L. LEVINE
MEMBER AIEE

F. W. BEEMAN

T. G. LeCLAIR
PRESIDENT AIEE

Newest addition to the Commonwealth Edison Company is the Ridgeland Station with an ultimate capacity of 600,000 kw. The result of long-range planning, the station has many modern features including centralized control, cyclone-fired furnaces, and hydrogen-cooled generators.

ON DECEMBER 7, 1950, the Commonwealth Edison Company of Chicago, Ill., dedicated its first completely new generating station in over 20 years. Ridgeland Station is planned for an ultimate capacity of 600,000 kw. Preliminary work was started in August 1947, and the first 150,000-kw unit was placed in service October 29, 1950. The second 150,000-kw unit is under construction and will be in service in 1951. The third and fourth units, already authorized, will require extension of the building to its ultimate capacity. Service is scheduled for 1953. The addition of the first Ridgeland unit brought the total net plant capability of the system to 2,802,000 kw.

This article covers the outstanding features of the station with detailed references applying to the installation for the first two turbine-generator units.

FUEL SUPPLY

THE STATION is located on the Chicago Sanitary and Ship Canal, see Figure 1. The waterway serves as a source of condensing water and also permits barging of the coal supply. Fuel for Chicago stations is supplied from the central Illinois coal fields, about 200 miles from the city. The economy of barge transportation permits transfer of coal reserve among stations on the waterway in time of need. Rail hauling facilities and a car dumper provide an alternate method of coal supply.

The coal-handling system consists of a traveling dockside bridge crane and conveyor belts and crushers, all making up an 800-ton-per-hour system. The entire system is controlled from one point, where a board shows, at all times, the operation of each portion of the system.

WATER SUPPLY

WATER SUPPLY for the steam generators and for general station use is obtained from Lake Michigan, about 10 miles away. Storage of 400,000 gallons at the station in two underground reservoirs assures adequate water at all times. The water treatment plant is designed for completely automatic operation.

Condensing water is drawn from the canal through a $15^1/_2$-foot tunnel. Condensing requirements are about 445,000,000 gallons per day for two 150,000-kw units.

STEAM GENERATORS

THE CYCLONE-FIRED steam generators, two per unit, are rated at 730,000 pounds per hour each at 1,900 pounds per square inch and 1,050 degrees Fahrenheit. With this method of burning, the coal needs only to be crushed to about 1/4-inch size rather than pulverized. This method of firing produces a maximum efficiency of combustion with a minimum fouling of the boiler tubes and stack gases. Electrostatic precipitators are used to reduce the stack discharge to a minimum.

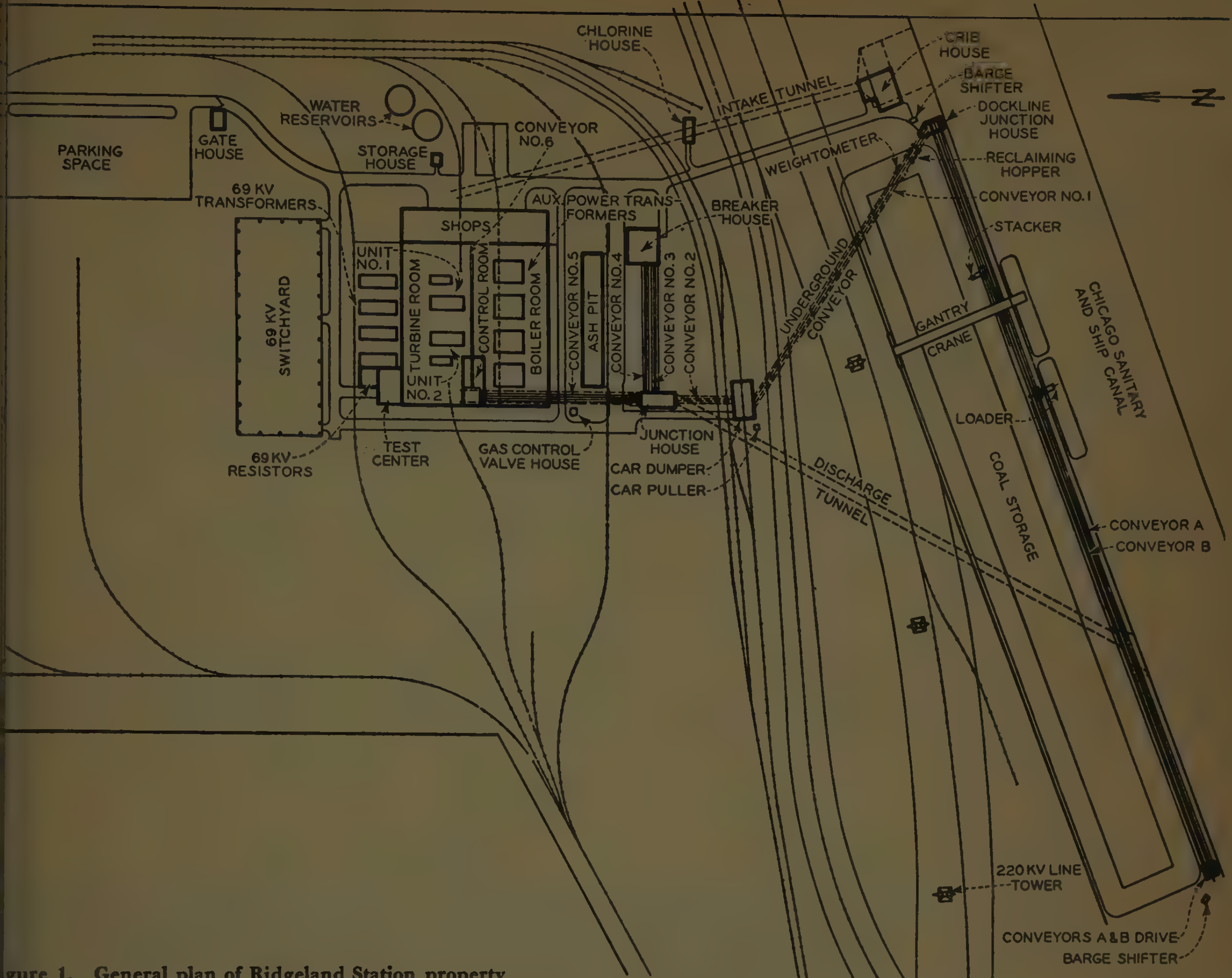
Because natural gas is available at times as an economic fuel, the boilers will be equipped for gas firing as well as coal firing. Electronic combustion control will regulate firing with coal or gas or a combination of the two. This system regulates fuel and air supply to maintain a predetermined steam supply. For flexibility of operation, it is possible to set any proportion of natural gas to coal consumption, and maintain the proportions under varying steam demand. All controls are located in the station control center.

TURBINE-GENERATORS

EACH OF THE FIRST two 150,000-kw units is supplied by two steam generators, with a total capacity of 1,460,000 pounds per hour at a throttle pressure of 1,800 pounds per square inch gauge at 1,050 degrees Fahrenheit. The four steam generators are connected to a common header. Each unit consists of a 50,000-kw 3,600-rpm high-pressure and a 100,000-kw 1,800-rpm low-pressure element normally operated cross-compound. The latter actually has an intermediate- as well as a low-pressure turbine on its shaft. Provision is made for independent operation of the low-pressure element by operating the boilers at about normal pressure and at suitably reduced steam temperature, and by having the steam go through a special throttle valve and governor that is used during such operation. This valve effects a suitable reduction in the pressure of the steam which is entering the intermediate turbine.

The hydrogen-cooled generators are designed fo operation at 85-per cent power factor at 0.5 pound pe square inch gauge. With hydrogen at 15 pounds pe square inch, the rated capability of the unit will be 1 per cent higher or approximately 203,000 kva. Rated voltage is 13.8 kv. Each generator is provided with a motor-driven exciter. A third exciter serves as reserve for the generators of either the high-pressure or low pressure elements. A diagram showing the 69-kv and 13.8-kv connections is shown in Figure 2.

D. L. Levine is senior engineer, Station Design Division, **F. W. Beeman** is assistan chief engineer, Calumet Station, and **T. G. LeClair** is chief electrical engineer of th Commonwealth Edison Company, Chicago, Ill.



gure 1. **General plan of Ridgeland Station property**

Automatic control of generator excitation has been esigned for two functions. For normal operation, a eselected generator bus potential will be maintained nder normal load variations. Automatic minimum-xcitation apparatus will insure stable operation with latively low field currents.

AUXILIARY POWER SUPPLY

A LL AUXILIARY POWER except one turbine-driven boiler feed pump and miscellaneous small auxiliary turbine-riven oil pumps is supplied from the electric system. For ach unit, two 8,000-kva transformers are connected directly the generator leads to provide power at 4,160 volts (see igure 3). Duplicate transformers are connected to the 9-kv bus so that auxiliary power is normally taken directly om the generators but may be supplied from the 69-kv ansmission system. The transfer is automatic in case of ilure of normal supply. A zigzag secondary was used the 13.2/4.16-kv transformers, so that with Δ-Y conection on all transformers, the auxiliary power supplies ould be in phase.

General station auxiliary power is supplied from the 69- system. One 10,000-kva transformer is connected to ach ring bus. The load is divided between these transformers on the 4,160-volt side, with automatic transfer in case of failure of either source of supply. Auxiliary equipment, driven by motors from 50 horsepower up to 3,500 horsepower, will operate at 4,160 volts; smaller equipment at 208 volts.

AUXILIARY POWER SYSTEM

THE AUXILIARY power system consists of five 4,160-volt substations and ten 208-volt substations. One 4,160-volt substation supplies large station auxiliaries as well as the six 4,000/208-volt substations for station lighting and miscellaneous small power. Two 4,160-volt and two 208-volt substations serve the power requirements of each generating unit.

The transformers feeding the 4,160-volt system are in compartments outside the building wall and are connected to the switchgear by a 3-phase metal-clad bus. Each substation has two parallel rows of switchgear connected by a bus crossing over the operating aisle. All switchgear is of the drawout type. The 4,160-volt circuit breakers are wheel-mounted. The 208-volt circuit breakers and contactors are stacked three high, with monorail facilities provided for handling removable elements. Cable is carried in open troughs in tunnels and in the cable rooms under the switchroom floors. All switchrooms are ventilated with filtered air in order to minimize maintenance requirements.

CENTRAL CONTROL

CONTROL of boilers, turbines, generators, major auxiliaries, auxiliary power, and transmission for all units is centered in a single control room, shown in Figure 4. The room is 40 feet by 96 feet at present, but will be extended to 160 feet long and will be approximately centered in the ultimate building structure. The room is air-conditioned and maintained under slight positive pressure for cleanliness. Considerable study was given to illumination. Fluorescent tubes above an egg-crate ceiling are designed to give a choice of 50 or 100 foot-candles on the bench boards.

Boiler controls (see Figure 5) are located on one side c the room and corresponding turbine-generator contro are positioned on the opposite side of the room. Transmission, auxiliary power, and station auxiliaries control are located at the eventual center of the room. In genera all instruments are installed on vertical back panels an controls are located on bench boards. Since the contro room is as much as 350 feet from items controlled, it wa necessary to select control systems and remote instrumentation methods with minimum lag characteristics Pneumatic relaying and electrical or electronic telemetering is used extensively. Steam, combustible gases, or high-pressure fluids do not enter the control room.

The combustion control and boiler feed pump contro are electronic controls adapted to pneumatic actuators Each boiler has two drum-level gauge glasses, one of which

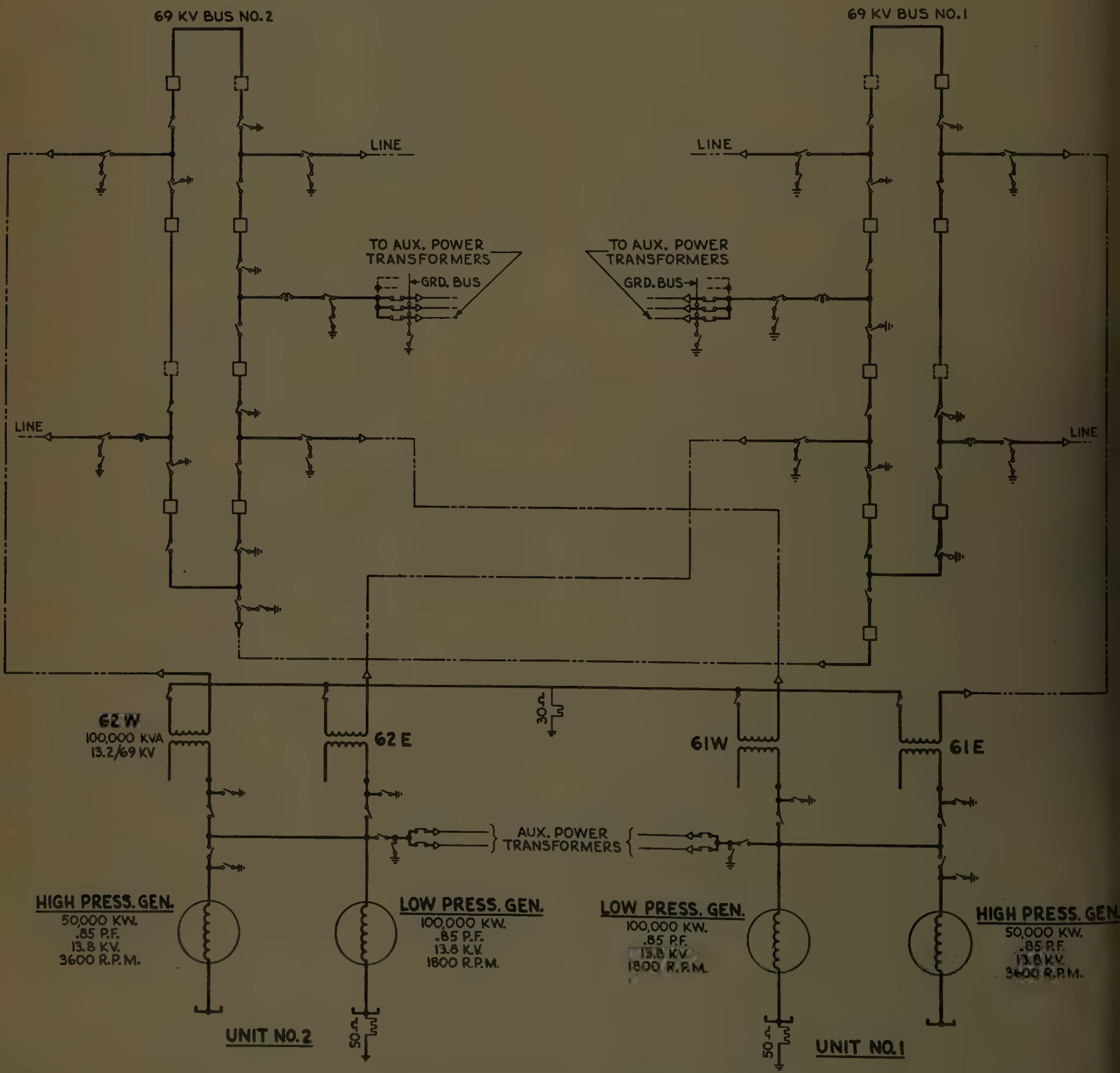
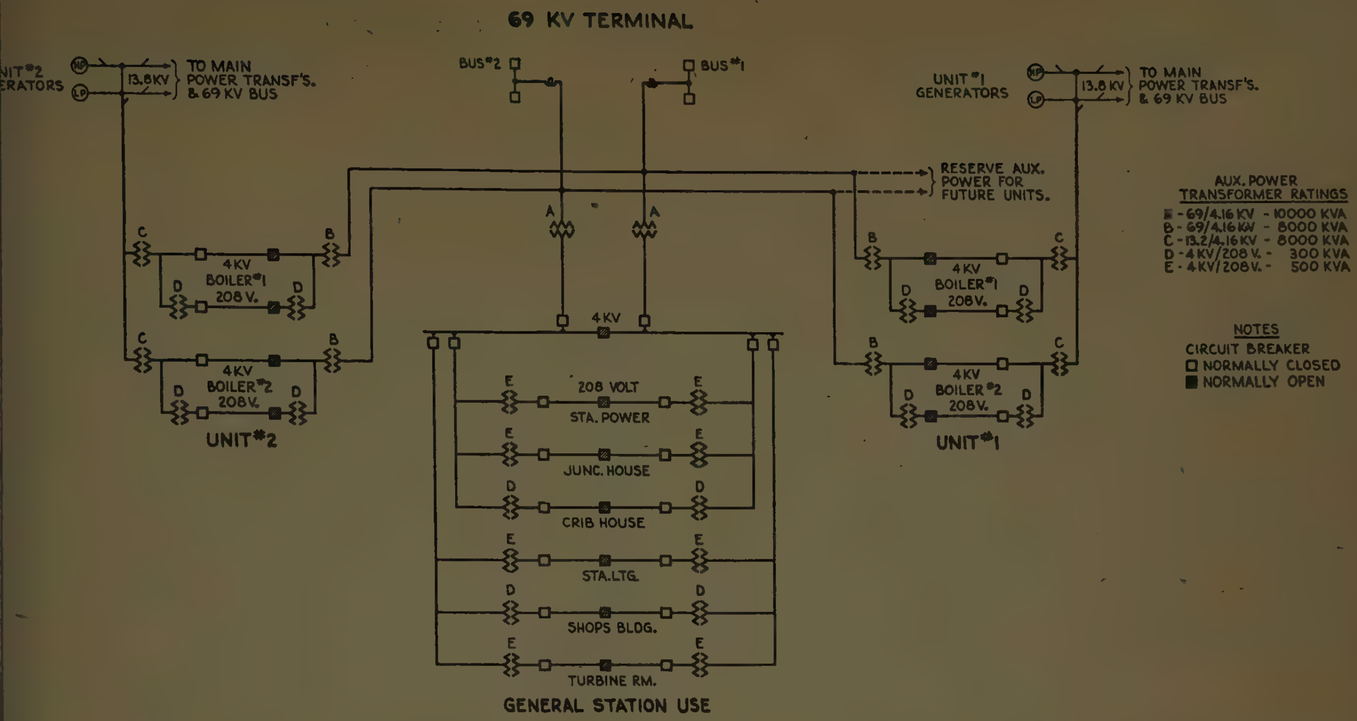


Figure 2. Electrical diagram showing the 13.8-kv and 69-kv connections



ure 3. Auxiliary power system showing the supply from the 13.8-kv generator leads and the 69-kv terminal as well he 4-kv and 208-volt arrangement. General auxiliary power is obtained from the 69-kv system; 50- to 3,500-horsepower auxiliary motors are connected on the 4,160-volt line; smaller equipment is on the 208-volt line

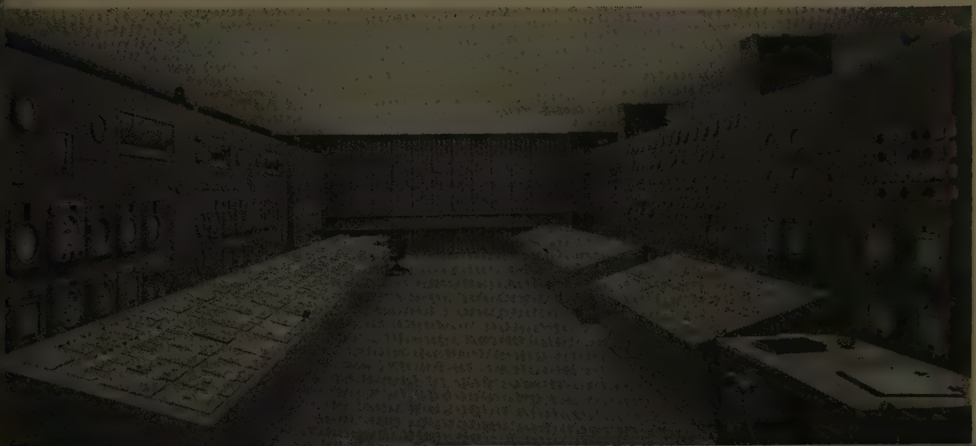
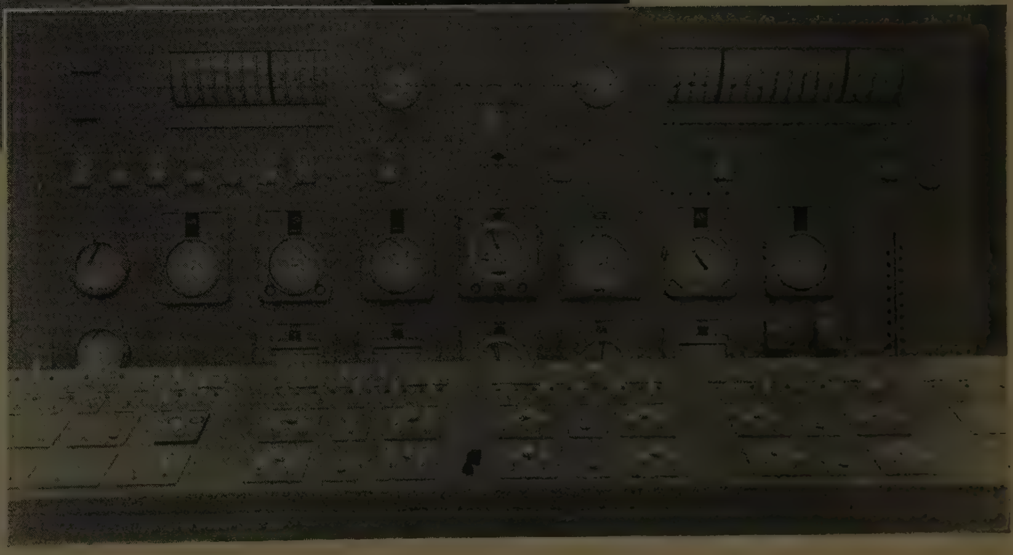


Figure 5 (below). A view of the control room showing the bench board and gauge board of one boiler



ure 4 (above). One end the control room showing iipment for the first unit. ler controls are on the left, bine controls on the right, l electric controls at the end is televised to the control room. This is supplemented by a telemetered drum-level recorder which is a component of the 3-element feedwater control. Use of alarms and automatic protective devices is much more extensive than in previous installations. Loss of ignition in a cyclone furnace is indicated by photocell-actuated alarm.

Audible alarms on the annunciator system are installed only in the central control room. Alarms are grouped into major and minor systems. Large "area" trouble lamps appear on sections of the control board to facilitate location of individual trouble lights.

INTERCOMMUNICATION SYSTEM

THE STATION has two public address systems supplementing normal telephone service, one for the coal-handling plant and another for the station in general. The two systems consist of 68 microphones and 115 speakers with provisions for additions. There are a total of 12 power amplifiers, each of 150 watts maximum output. Speakers are dispersed throughout the buildings and about the property, as necessary, to provide complete coverage. Generally, microphones are located at strategic spheres of equipment operation and near speakers. A unique feature of the installation is a carrier-current system which extends from the bridge crane to various parts of the coal-handling system.

ARCHITECTURAL FEATURES

ARCHITECTURALLY, Ridgeland Station represents a complete departure from previous design of generating stations in the company. Lower sections of the outer walls are architectural concrete and upper sections are fluted aluminum panels. The metal walls are prefabricated double-sheet construction with 16-gauge striated aluminum on the outside, 18-gauge zinc-coated steel sheet inside, and $1^1/_2$ inches of insulating Fiberglas between. Supplied in approximately 2-foot by 12-foot panels, the panels were welded directly to building steel. Window sash and ventilating louvers are aluminum.

Office and utilities space is at the far or east end of the building, as shown in the cover picture. The 213-foot stacks with "bottle top" contour and banded with international red and aluminum were as high as could be erected because of the proximity of the station to the glide-path of the Midway Airport. Wind tunnel studies at the University of Michigan dictated the stack design and building contour. Sloping walls of the coal conveyor housing over the boiler house roof can be seen. The junction tower in the coal conveyor system is in the foreground.

LIGHTING

THE ROADWAYS on the property are lighted by mercury-vapor highway-type lights of 21,000-lumen capacity. The coal yard and dock area are floodlighted from two 100-foot towers to permit night operation of the coal system.

The turbine room and shops are provided with a combination of incandescent and mercury-vapor lighting. With each 400-watt mercury-vapor fixture 750 watts of incandescent lights are used. The effective light intensity is 25 foot-candles on the turbine room floor. This combination of lighting was found to give a close approximation of daylight.

Obstruction lights on the end stacks are mounted on hinged booms at the nozzle sections, and on swivel rings for all stacks at the mid section and nozzle sections to facilitate maintenance. Lights are controlled by means of photocells and duplicate circuits with automatic throw-over are provided.

CONCLUSION

THE NEW STATION is representative of the latest engineering advancements of the electric power industry. Long-range advance planning led to the acquisition of the plant site over 25 years ago. What was wasteland then is now the center of a rapidly growing industrial and residential load area. Structural design made use of the most economical materials and methods available at the time of construction. The output of the station that will be available by 1951 will be readily absorbed in the existing transmission system to satisfy the ever-increasing demand for electric power in the Chicago area.

Spider Framework for Rotor in Process of Being Welded

This 79-ton spider being welded at the East Pittsburgh, Pa., plant of the Westinghouse Electric Corporation is the inner framework for the rotor of one of the 108,000-kw waterwheel generators for the Grand Coulee Dam power plant. The rotor measures 31 feet in diameter and, when completed, will weigh 542 tons. It will rotate at 120 rpm

Design of the Naval Research Laboratory Computer

D. H. GRIDLEY   B. L. SARAHAN

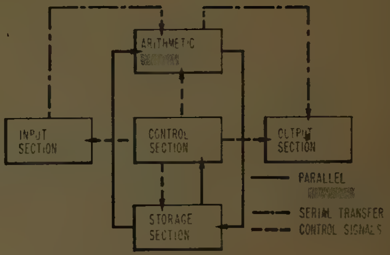


Figure 1. Block diagram of the computer showing paths for transfer of information

THE NAVAL Research Laboratory Electronic Digital Computer (NAREC) is to be a general-purpose ctronic digital computing machine capable of high-eed computations with binary numbers having a pre-ion of 44 digits (about 13 decimal digits). The high-eed and precision characteristics of the computer will ake it especially valuable not only for reduction of experi-ental data but also for the solution of systems of linear uations with a large number of unknowns, nonlinear fferential equations, and other problems involving mputations of similar magnitude. The design of the AREC was begun in July 1949, and it is hoped that the mputer will be placed in operation by January 1952 ith an additional six months being required to place the mputer on an efficient operating schedule.

The circuits of the NAREC, see Figure 1, are divided to five sections: input section, arithmetic section, storage ction, control section, and output section. In addition, uipment is provided for preparing the magnetic tapes ed by the input section and for transcribing the informa-on recorded on the magnetic tape by the output section. he main unit of the NAREC is 30 feet long, 8 feet high, d 3 feet wide. It consists of two magnetic tape readers nput section), four magnetic tape recorders (output ction), 45 cathode-ray tubes (electrostatic storage portion the storage section), and 1,800 vacuum tubes and 6,000 ystal diodes (mostly the arithmetic and control sections). magnetic-drum-type storage is contained in a separate it.

The necessary input information (both numbers and erational instructions) must be transferred from the agnetic tape of the input section to the electrostatic orage of the storage section before the NAREC may be aced in automatic operation. The magnetic tape ader of the input section senses the magnetized pulses plus and minus polarity on the tape and transmits rresponding binary indications serially to the arithmetic ction. When the arithmetic section has received 45 nary digits (a word), the complete word is transferred one of the storage locations of the electrostatic storage. l or any part of the 1,024 storage locations of the electro-atic storage may be filled during the input operation.

Words (generally, decimal numbers) may be extracted om the electrostatic storage of the storage section and corded on magnetic tape as part of the automatic opera-on of the computer. A word is recorded serially from e arithmetic section, and the recording process is inde-ndent of the other computer operations. With the magnetic tape of the recorder moving at 30 inches per second and an anticipated recording rate of 75 pulses per inch, a maximum of 50 45-binary-digit words may be recorded during a 1-second period. The necessary synchronizing and identification pulses are recorded on other channels of the tape.

An electrostatic storage similar to that developed by Professor F. C. Williams of the University of Manchester (England) provides for the storage of 1,024 words. Any one of these words may be made available to the arithmetic section of the computer in ten microseconds. A magnetic-drum-type storage with a capacity of 2,048 45-binary-digit words serves as a reservoir for the electrostatic storage. Groups of words are received or transmitted to the electrostatic storage as required. For such a function, the magnetic storage need not be capable of receiving or transmitting words at the high speeds provided for in the electrostatic storage.

The arithmetic section, which performs all operations in the binary number system, consists of five registers and a parallel adder. Auxiliary circuits are provided to control the registers and the adder in the performance of subtraction, multiplication, and division. The addition and subtraction operations (including transfers and order interpretation) require 30 microseconds; the multiplication operation 300 microseconds; and division 400 microseconds. The conversion from decimal input data to binary data and from binary data to decimal output data is performed by the computer as a part of the computation.

The series of instructional words (pairs of single-address orders) corresponding to the desired sequence of operations is inserted into the electrostatic storage of the storage section during the input operation. The control section of the computer extracts an instructional word from this storage, interprets it, and activates the circuits in the other sections of the computer involved in the performance of the operation specified. Upon the completion of the two orders of the word, a second word is extracted from the storage section and the interpretation and activation processes repeated. This sequence of word selection and the performance of orders is continued until the sequence of instruction words is completed. Flexibility of coding is provided by orders which alter this strictly sequential process of instructional word selection.

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gest of paper 50-262, "Design Objectives of the Naval Research Laboratory Electronic gital Computer," recommended by the AIEE Committee on Computing Devices d approved by the AIEE Technical Program Committee for presentation at the EE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Not eduled for publication in AIEE *Transactions*.

H. Gridley and B. L. Sarahan are with the Naval Research Laboratory, Washington, C.

A Medium-Haul Carrier Telephone System

H. H. SMITH

IN THE LAST 30 years the rise of dialing requirements for local and long distance circuits, coupled with increased plant construction costs, has made the older types of carrier telephone systems obsolescent. It was found that there is a distinct field for medium-haul carrier telephone systems, capable of transmitting up to about 12 decibels above, and receiving down to about 15 decibels below, the level at the switchboard at the transmitting end, and providing circuits with 2-wire net circuit losses of two to six decibels. Such a system should transmit voice frequencies from about 300 to 2,700 cycles with a rather flat characteristic. The modulator and demodulator carrier oscillators should be stable to about three cycles to permit use of voice-frequency carrier telegraph systems.

The signaling method should not interrupt the basic carrier channels so that speech-plus-telegraph or signaling may be used. The signaling system should provide a separate signaling path in each direction not interfering with normal functioning of the channel, be immune from false operation by speech currents, and be capable of handling all types of signaling, including ringing, telephone dialing and supervision, railway selector impulses, and other miscellaneous uses, not necessarily related to the speech currents transmitted in the voice-frequency band. The terminating arrangements of both signaling and speech equipment must be sufficiently flexible to be adapted readily to the various types of connecting circuits and line conditions. It should be possible to apply the same equipment to stable broad-band links to obtain twice the number of channels as when applied to wire lines. It is preferable for a medium-haul carrier system to be stackable so that channels may be added as required by traffic growth. By-pass arrangements also must be provided. Maintenance and installation should be possible with relatively simple test equipment, and line-up and maintenance adjustments should be made by controls with graduated scales to permit the technical man to be assisted by helpers with little training. It is important that the equipment be as compact as consistent with convenience of maintenance.

The Federal *9-H-2* medium-haul carrier telephone system was designed to meet these requirements. It provides three stackable channels operating between 3.6 and 35 kc. All of the equipment for each channel is contained on a single panel with over-all front dust cover, the panel being 19 inches wide and 8$^3/_4$ inches high. Included with the channel equipment are also the a-c power supply for the channel, the line filter for the lowest channel, and plug-in signaling transmitting and receiving relays. Only one line filter is used for the channel terminals at each end of a system. Relative to one milliwatt test signal applied to the 2-wire drop, the normal sideband transmitting level to line is 12 decibels above one milliwatt, and minimum line receiving level is 18 decibels below one milliwatt. Over-all 2-wire loop gain is about 26 decibels. On a 4-wire drop basis, over-all loop gain is about 43 decibels. The over-all channel transmits voice frequencies from 300 to 2,700 cycles between points of 2-decibel rise, or from 100 to 3,000 cycles between 10-decibel points.

Frequency allocations agree with accepted directional bands between 3 and 30 kc. The suppressed carriers and upper and lower sidebands (USB and LSB) follow:

Channel 1: West—LSB, 7.0 kc; East—USB, 9.0 kc.
Channel 2: East—LSB, 17.0 kc; West—USB, 19.5 kc.
Channel 3: West—USB, 26.0 kc; East—LSB, 35.0 kc.

Two 1-way signaling channels are provided per channel, spaced 3.4 kc away from the suppressed carrier, on the same side as the transmitted sideband. The signaling current is generated at line frequency, not passing through the modulator, and is keyed by a plug-in transmitting relay which may be either an a-c or double-winding d-c type. At the receiving terminal, it is demodulated to 3,400 cycles, is limited and amplified; then it operates a plug-in receiving relay. This relay may be wired to repeat dial impulses or d-c signals or to apply ringing current to the drop, as required by the application. An important feature is dial pulse ratio control in the signal receiving circuit, whereby compensation may be made by turning a control, for external impulse distortion up to about ten per cent in either direction. By this means, distortion inherent in associated trunk equipment up to a reasonable amount may be readily neutralized. For isolated terminal installations serving telephone sets, the power supply equipment can supply both direct current for energizing a common battery telephone and alternating current of mains power frequency to operate the ringer.

The panel has five controls with graduated dials which permit adjusting the combined sideband and signal transmitting level, the combined sideband and signal receiving level, the audio output level to the drop, the sensitivity of the signal receiving circuit, and the dial pulse ratio. Adjustable carrier leak resistors are included in the modulator and demodulator circuits. The relative signal transmitting level may be changed by a soldered tap. Convenient test points in both audio and carrier circuits as well as in d-c signal transmitting and receiving leads are provided by means of inexpensive removable U-links, with pin-jacks fitting standard test lead tips. Using the factory calibrated transmitting level adjustment, a channel may be lined up for operation with only a 1,000-cycle 1-milliwatt oscillator and a rectifier-type meter.

Digest of paper 50-242, "A Medium-Haul Carrier Telephone System," recommended by the AIEE Committee on Wire Communication Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

H. H. Smith is with the Federal Telephone and Radio Corporation, Clifton, N. J.

Procedures for Obtaining Registration as a Professional Engineer

N. L. FREEMAN
MEMBER AIEE

The author presents a review of the procedure involved in becoming a registered engineer and its advantages to the individual and the profession as a whole. A list of national registration boards and boards of engineering examiners is included.

THE LEARNED profession of engineering is as old as history but it was ot until modern times that e public, for its own protec- on, began to require those ho sought to practice it to rst satisfy certain minimum atutory requirements. The Iroquois Theatre fire in hicago and other disasters which were manifestations of a ore intense civilization served to focus the public eye upon ngineering and its responsibilities of life, health, and roperty. In 1907 the state of Wyoming became the first adopt an engineering registration or license law. Now l 48 states and three of the territories have such laws.

Since the registration of engineers is for the protection of e community, the public must be the first consideration hile the profession and the individuals in it must rank sec- nd. The public is interested in protecting itself from e incompetent and the unprincipled ones who seek to ey upon it in the name of engineering. It wants an vailable supply of dependable engineers. The public is ot particularly concerned about providing a better way life for engineers except as they serve the interests of the eople. However, in making engineering a legally regu- ted profession, engineers were given another oppor- nity to become a coherent body with unified interests.

Certain considerations characterize the registration laws lopted by almost every state. The most important of em is that only those who have satisfied the requirements escribed by law may register as professional engineers hile the profession has been given the responsibility of ying whether or not applicants have met the require- ents. The basic philosophy is essentially that, for the otection of the public, the exclusive right to practice in e field of engineering has been given to those who satisfy e legally prescribed qualification requirements. The ofession has the task of determining what the exact re- uirements are and when they have been satisfied. The alue of an ancient and respected custom whereby the ualifications of learned men are judged by others of milar learning who have already established their quali- cations is satisfied. Thus, beyond a general outline of hat the public requires, the profession is expected to lminister itself and is given this right of self-preparation nd self-determination. The profession determines what nstitutes adequate education and experience and, rough board action, authorizes an applicant to practice ly when he is considered to be qualified.

Not only does this serve the best interests of the people but it also places an obligation upon those engaged in engineering. Many regard this duty with apathy and fail to realize that professional practice carries with it a special form of citizenship and a preferred position in society, which should combine us into a body with common interests which are above and beyond the limited responsibilities of technicians.

With the exclusive right to practice engineering also came other important privileges and obligations. An engineer's opinion is the respected judgment of a professional man, accepted as such in court and by the public. The professional engineer has a greater responsibility in the community due to his position of trust in the profession. Heretofore the profession has disowned its birthright of unity. Of the numerous active engineering societies, not one has a membership greater than one-tenth of those who claim to earn their livelihood in engineering. Perhaps by thinking and acting as a single unified profession we can recapture that which we have thrown away. Unless we make an active, organized effort to administer our profession, it will be directed by others through our default.

If the future of our profession lies in this direction and unity is to be achieved by a registered, professional engineering effort, then each of us should make an effort to become registered. Although the steps to be followed are all for the purpose of determining whether or not applicants are qualified to practice, the exact procedure of each state has been developed around the conditions peculiar to it. Obviously Wyoming and its irrigation problems differ greatly from those of the densely populated eastern industrial states such as New Jersey, New York, and Pennsylvania. Just as no two states have identical constitutions, no two registration laws could be expected to be exactly alike. All seek to determine that applicants are adequately mature, of good moral character, properly trained and sufficiently experienced to insure competence in assuming professional obligations and duties.

Registration Procedure. (As the author is affiliated with the New York Board and can speak with authority only in that connection, the following instructions are patterned after the procedure followed in New York state.) In each state there are certain statutory qualification requirements and the application forms are designed around them and arranged to include whatever additional information

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N. L. Freeman is Secretary of the New York Board of Examiners of Professional Engineers and Land Surveyors, Albany, N. Y.

each board believes necessary for its considerations. The applicant is required to make affidavit concerning the truth of the statements contained in the completed form. The procedure to be followed is:

1. Obtain the required forms, instructions, and a list of the qualification requirements. Sometimes these are available through engineering society local offices but the board secretary is always in a position to supply them.
2. Execute the application forms according to instructions, being careful to supply all the requested information.
3. Describe experience accurately and concisely so that for each engagement the board will know the title under which you worked, your employer and location, and what you did while so employed. If you want to submit greater detail, do so in a separate, supplemental description.
4. In supplying reference names or endorsements, if required, select those upon whom you can depend to give accurate, dependable replies to the board.
5. Mail to the secretary your completed application, the required fee, and whatever supporting documents are specified in the instructions.

Facts Concerning Application. Usually the name of the applicant is the first required information. This should be your legal name and if there has been a change made by court order so that parts of your training and experience appear under different names, a copy of the court order should be made available to the board.

The question of maturity is left to the judgment of the boards of 27 states and territories, while 13 of them require the applicant to be at least 21 years of age. Another places the minimum at 24 years and ten say he must be at least 25 years old. Thus the date of birth is always asked and often the place, too. Sometimes a board requires this to be verified by a copy of the birth certificate. In 11 states requiring citizenship or a legal declaration of intention to become one, a foreign-born applicant may be required to send in his original papers or those of the parent from which his status is derived. Of the 11, two states accept Canadian as well as United States citizens, seven require citizenship or a legal declaration of intention, while two expect a fully established status. Documents of this nature are irreplaceable and the writer suggests that they be withheld by the applicant until officially instructed to submit them. Then they should either be sent by registered mail or personally taken to the authorities.

Not all qualification requirements are specified in the law of each state or territory. However, good moral character is one which appears in 47 statutes, while the remaining four leave it to the opinion of the board. The methods by which character is established are, in general, by references although these procedures vary considerably among the different boards. All require an affidavit with the application and, in addition, by various methods they obtain statements from the references. Some require reference endorsements by licensed professional engineers. The judgment of professional engineers regarding the character and degree of responsibility is preferred.

Graduation from a recognized engineering course, or the equivalent in training and experience, is required by 48 states. Almost all have examination provisions with varying degrees of board discretion in their usage. Most of them permit the board to accept many years of experience as having demonstrated those qualifications we seek to ascertain by written examinations. However, some go further and require that, in addition, the applicant must show that he has attained recognized standing in the engineering profession if he is to receive favorable consideration because of his long experience. Such provisions are not to be confused with "grandfather clauses" which are those whereby applicants who can successfully show that they have had a prescribed number of years of engineering experience are automatically registered. A grandfather clause is an essential ingredient in the initial phases o registering in a profession and is usually removed from the law after the first few years. Thus, almost none of the current engineering laws retains one that is now effective.

In adopting registration statues most states and territories have felt that an applicant should have practical experience in engineering before he could be expected to practice safely and dependably and, for this reason, have made experience a statutory qualification requirement. This experience must be of a grade and character satisfactory to the board. The acceptability of it may vary between the states. The New York board believes that a graduate can obtain satisfactory experience only in a position or positions for which a technical education is a prerequisite. While few go into positions of responsibility immediately upon graduation, the succeeding years should show a marked advancement towards greater responsibility. Experience descriptions should make clear the applicant's progress.

Examinations. Many states now require applicants to pass written examinations as part of the qualification requirements in engineering. While most boards have the authority to accept many years of outstanding achievement as adequate evidence of qualification, few engineers can afford to wait so long or to gamble that a board will eventually rule that their experience records satisfactorily demonstrate qualification. It is not advisable for engineer to delay for the purpose of avoiding examinations. While the value of examinations as a measure of engineering qualifications is always debatable, they are often the board's only recourse when considering young engineers.

Examinations usually are constructed primarily to tes the technical training of the candidate; succeeding questions require the use of engineering judgment and experience must be relied on for satisfactory answers. Many examinations are of the "open book" type but not all o them. In preparing for examinations the candidate should find out their length and scope as well as the circumstance under which they are to be given. Most of us work i rather narrow fields and before taking examinations shoul do some reviewing in the subjects used less frequently Refresher courses are offered in many parts of the countr to assist in this matter. In addition, it is suggested that th candidate plan his time during the examination to b able to answer enough questions to earn a passing mark

Almost half of the states have a provision to facilitat the taking of examinations by giving part of them imm tely after graduation when technical training is fresh the minds of graduates. These are called the pre- inary examinations and those who pass them become ineers-in-training. After these men accumulate enough sfactory experience they are eligible to take the nainder of the examinations. The author recommends procedure to all recent graduates both for its con- ience and because of the fact that those taking the minations in this way are more successful than those o wait until they are eligible to take all of them at once. An engineer who earns his registration by passing written minations in one state is in a much stronger position en he seeks a license in another based upon the one he sesses. This kind of a record is much more acceptable all Boards of Engineering Examiners than any other. Boards of Registration or Boards of Engineering Exami- s are

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201 State Capitol Building, Cheyenne

Induced Currents in High-Capacity Bus Enclosures

S. C. KILLIAN
MEMBER AIEE

IN RECENT YEARS the air-insulated metal-enclosed high-capacity bus has come into wide use in central stations. These busses are built in a variety of designs with three basic configurations: nonsegregated phase, segregated phase, and isolated phase. They vary mainly in construction between phases. In addition to this, the only outstanding difference is the presence or absence of considerable circulating current in the bus housings.

These circulating currents may be allowed to flow as in the unsegregated- and segregated-phase enclosures where they will heat the enclosure but protect adjacent building steel from inductive and magnetic heating because their field will oppose the field of the main conductor. In the isolated-phase enclosure, where the phase ducts are completely separated from each other, circulating currents cannot flow between phases. The individual phase ducts also are broken into sections by insulating strips which further reduce these currents. Heating in these enclosures will be small but adjacent steel will not be protected from inductive and magnetic heating. Other external means then must be used to keep the temperature of this steel at reasonable values. Where circulating currents are allowed to flow in the enclosure, a careful choice of enclosure material must be made, as this will determine the losses which occur in the enclosure and the voltage drop caused by the main bus.

The induced currents in a nonsegregated- or segregated-phase bus will flow as shown in the simplified diagram of Figure 1. Instantaneous current may be considered to flow in the conductors as shown by the heavy arrows. The currents induced in the top and bottom sheets then will appear (dotted lines) and will flow so as to generate fields whose flux will oppose the field of the main conductor through as much duct length as possible. This then requires the closing of these circuits in the very edges of the sheets as shown by the double dotted lines. This end effect, with its high current concentration, produces a comparatively high temperature rise. Rises in all other parts of the enclosure will be much less.

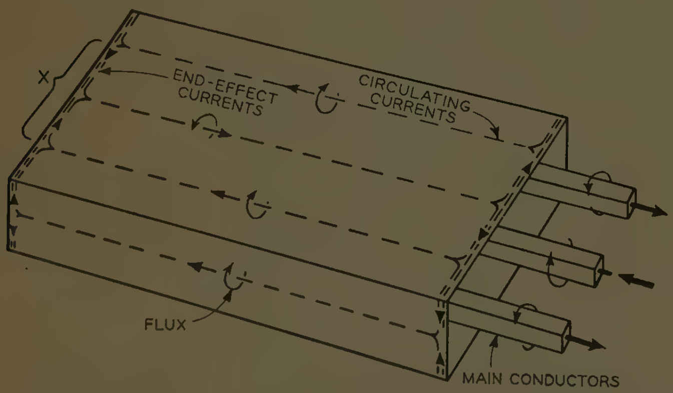


Figure 1. Simplified diagram of induced current flow in enclosure

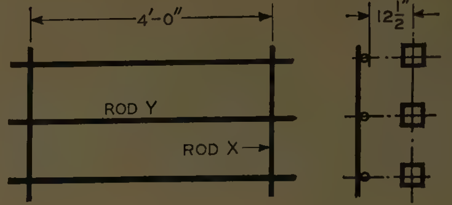


Figure 2. Simpl grid used to stud the behavior of in duced currents

In order to study these circulating currents, their magnitude, distribution, power loss, end effect, proximity effec their efficiency as counterflux producers, and their effec on temperature rises, many mock ducts were built of rod and special sheets. One simplified grid of five rods wa used to represent the top sheet of a duct, see Figure 2 Experiments made on this dummy duct showed that as th rod resistance increased the current decreased. An optimum rod size existed when the diameter of the coppe rod was about three-fourths of an inch: at that point th power loss was greatest. This maximum point also wa seen when losses occurring in sheets of various materia and thicknesses were plotted.

On the basis of the many tests performed and on basi electrical theory, the following conclusions can be mad for segregated- and nonsegregated-phase busses:

1. Induced currents in enclosures are proportional t main currents.
2. Decreasing phase spacing of the mains decrease induced currents.
3. Voltages induced are proportional to enclosur length and to the current in the mains.
4. Circulating currents flowing in enclosures reduc the reactances between the main conductors.
5. Circulating currents in enclosures do not increas with the lengthening of the bus after a certain length, sa 10 to 20 feet, is exceeded.
6. Large end-effect currents will flow at the end of eac enclosure section, and to avoid heating from these curren at every enclosure joint all sections should be electricall bonded together.
7. Proximity effect in enclosures insulated from eac other must be considered, since this produces additiona heating.
8. On the basis of power loss, an enclosure materia can be selected which will provide minimum loss consis ent with necessary structural strength and economic r quirements.
9. Induced currents in enclosures reduce the fiel strength outside the enclosure to about ten per cent of tha without enclosures.

Digest of paper 50-222, "Induced Currents in High-Capacity Bus Enclosures," recom mended by the AIEE Committee on Power Generation and approved by the AI Technical Program Committee for presentation at the AIEE Fall General Meeti Oklahoma City, Okla., October 23–27, 1950. Scheduled for publication in AI *Transactions*, volume 69, 1950.

S. C. Killian is chief engineer, Delta-Star Electric Company, Chicago, Ill.

Neutral Inversion of a Single-Potential Transformer

L. L. GLEASON
ASSOCIATE AIEE

MANY single-potential transformers are connected line-to-ground on normally grounded circuits that y become an isolated delta by circuit switching (see ure 1).

Neutral inversion has occurred with this circuit which s resulted in sustained line-to-ground potential of 56 on a 34.5-kv insulation class power transformer. The ssibility of this phenomenon occuring is increasing with reased use of primary, secondary, and other networks ich provide the source for energizing the circuit.

The position of the neutral or ground on a delta circuit dependent on the phase-to-ground impedances. These pedances to ground consist generally of distributed pacitance, and for the condition of the normally balanced pacitance the neutral will be at the center of the delta. y application of other impedances on one phase-to-ound will change the impedance balance and will shift neutral from the center. The voltage across the un-lancing impedance is given by the equation of Figure 1, d for inductive reactance the voltage is plotted as curves 2; and 3 of Figure 2.

The most unstable neutral of a delta circuit is the one th the smallest phase-to-ground capacitance, and is the tributed capacity of the delta winding only. The pedance of the potential transformer without burden its excitation impedance. This impedance is variable th respect to the voltage and cannot be expressed as an uation, but, by neglecting the harmonics of the excita-n current, an impedance curve with respect to the ltage may be plotted from the magnetization curve. e intersection of the impedance curves with the voltage aracteristic curves of Figure 2 is the voltage on the tential transformer during an isolated delta condition. hen this point is in quadrant 4 the voltage on the po-ntial transformer will be shifted in phase approximately 180 degrees or the neutral has inverted about the phase of the potential transformer connection. Without corrective secondary burden, potential transformers *B*, *C*, and *D* all have neutral inversion, but transformer *A* is stable and produces little neutral shift.

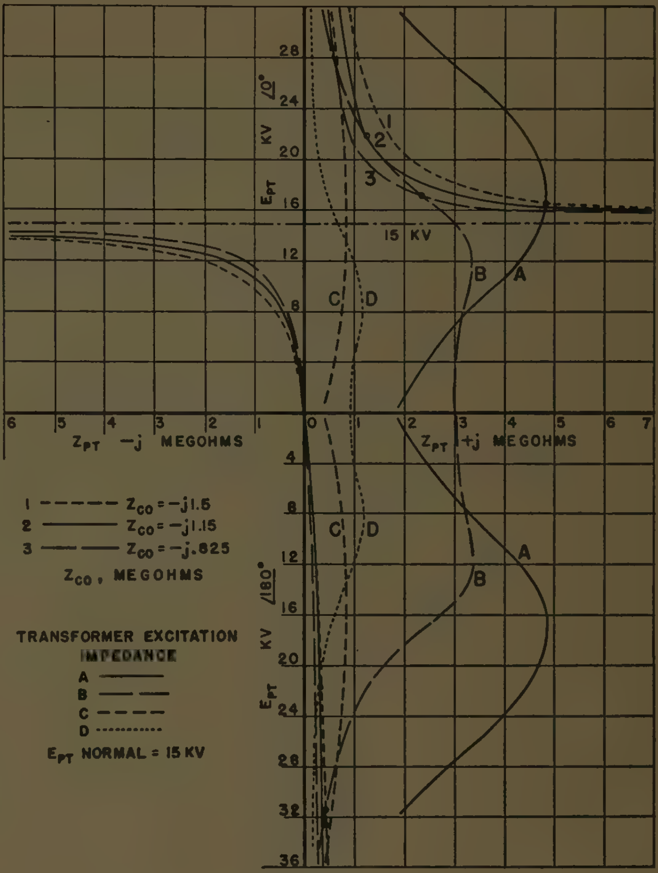
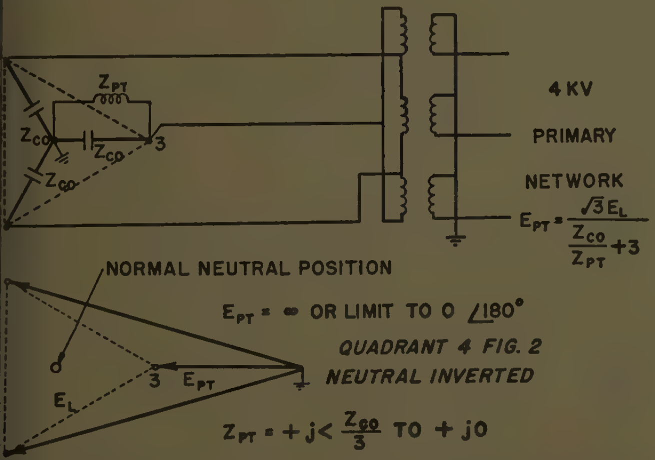


Figure 2. Graphical solution of neutral stability points. No secondary burden

The application of a capacitive secondary burden to potential transformers introduces a capacitive impedance in parallel with the normal phase capacitive impedance and potential transformer excitation impedance.

Several tests were made on the equipment used in Figure 2 for which oscillograms of the inversion were made. The tests substantiated the results of Figure 2 both for unburdened and burdened potential transformers.

It is concluded from the work done on this subject that potential transformers purchased for this service must have excitation impedance characteristics equal to transformer *A*, and that capacitor secondary burden can be used with good results on transformers similar to *C*.


Z_{PT}
Z_{CO}
Z_{CO}
Z_{CO}
3
4 KV
PRIMARY
NETWORK
$E_{PT} = \frac{\sqrt{3}E_L}{\frac{Z_{CO}}{Z_{PT}}+3}$
NORMAL NEUTRAL POSITION
E_{PT} = ∞ OR LIMIT TO 0 ∠180°
QUADRANT 4 FIG. 2
NEUTRAL INVERTED
3
E_{PT}
E_L
$Z_{PT} = +j < \frac{Z_{CO}}{3}$ TO $+j0$

ure 1. Isolated 3-phase delta with a single line-to-ground potential transformer

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Digest of paper 51-14, "Neutral Inversion of a Single-Potential Transformer Connected Line-to-Ground on an Isolated Delta System," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

L. L. Gleason is with the Lighting Department, City of Seattle, Seattle, Wash.

The Field Testing of 220-Kv Air-Blast Circuit Breakers

L. R. BERGSTRÖM U. SANDSTRÖM

Circuit-breaker problems at very high voltages have been studied in Sweden to show what will happen to the circuit breakers on the new 380-kv line. A discussion of the tests and their results are presented here.

THE FIRST 380-kv line[1] in the world, a 593-mile line from Harsprånget to Hallsberg in Sweden, soon will be in operation. In the absence of any previous experience of long-distance power transmission at this elevated voltage, there were many problems which first had to be solved by experiment and investigation. Some of these concerned the circuit breakers used in the 380-kv line. Among other things, it was necessary to find out what overvoltages were to be anticipated due to switching operations in order to determine the insulation level. The investigation into circuit-breaker problems was carried out in field tests on a 220-kv air-blast circuit breaker, jointly arranged by the Swedish State Power Board and Allmänna Svenska Elektriska Aktiebolaget (ASEA) in February and March 1948.

The primary object of these tests was to determine the magnitude of the overvoltages arising when switching various lengths of unloaded transmission line and transformers loaded with reactors used for control regulation. Another object of the test was to investigate the reduction in these overvoltages that could be accomplished by fitting a nonlinear damping resistor across the circuit-breaker gap.

As the 380-kv system is to be carried out with a direct-grounded transformer neutral, the majority of the tests were made with direct-grounded neutral. However, a number of tests also were made with the neutral grounded through an impedance; this was done with regard to the existing 220-kv system which is equipped with Petersen coils.

The circuit breakers in the first stage of the Swedish 380-kv system will be subjected to appreciably greater voltage stresses on each circuit-breaker element when interrupting the line than the 220-kv circuit breaker is, and for this reason many of the tests were carried out with two of the six circuit-breaker elements short-circuited.

These field tests were carried out on a standard 220-kv air-blast circuit breaker of ASEA's manufacture, type designation *HTFY 200/606*, shown in Figure 1.

Uniform voltage distribution across the six circuit-breaker elements is achieved by means of a 300,000-ohm grading resistor, mounted in the circuit-breaker elements. The contact stroke in each element is 25 millimeters, and the contacts are so devised that they reclose a certain time after circuit interruption has taken place. Before reclosing, however, the series-connecte isolator opens so that a visible air break is obtained.

All testing was carrie out at the Stadsforsen powe station, using one of the loca 40-megavolt-ampere generators. Owing to the comparatively low generator outpu the station impedance was rather large so that the lin capacitance had a considerable influence on the voltag subsequent to interruption.

DIRECT-GROUNDED SYSTEM

FIGURE 2*A* represents a single-phase line diagram a used in the test circuit, and Figure 2*B* denotes th test circuit breaker which had only four circuit-breake elements connected in during practically all of these tests The tests were carried out at a voltage of 220 kv and frequency of 50 cycles per second, with the exception of th 480-kilometer line, when the frequency was reduced t 40.5 cycles per second. Four lengths of line were investigated, 72, 157, 239, and 480 kilometers. In three of th 33 tests carried out restriking occurred (see Table I).

With an air-blast circuit breaker having a short contac stroke, it usually is possible to interrupt the current as th phase passes through the first zero subsequent to contac separation. The phase displacement is generally close to 9 degrees so that the line will carry direct voltage of the sam magnitude as the voltage amplitude prior to interruption Travelling waves in the line may cause some change in th line voltage immediately after interruption, but thei effect is negligible, at least in the case of the line length used in this test.

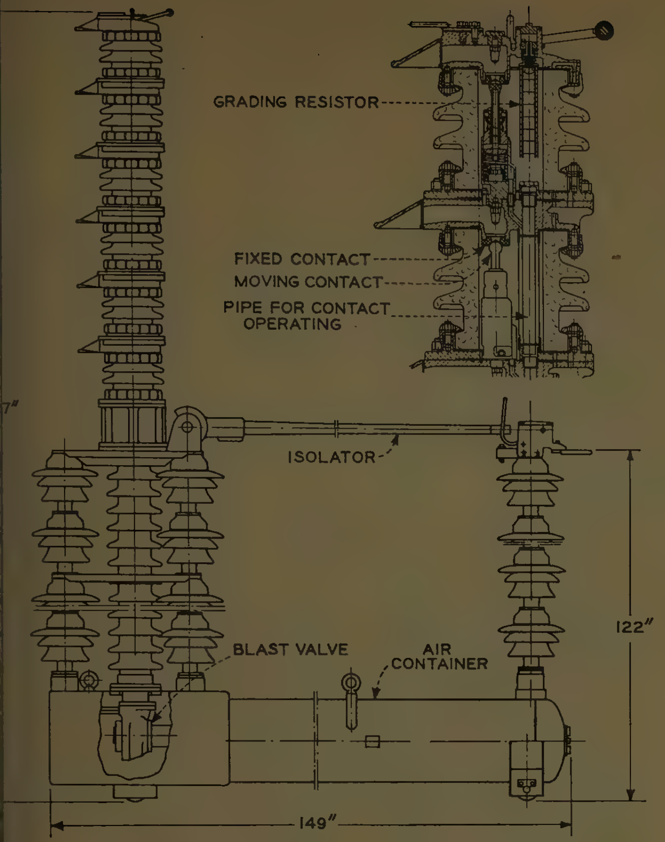
Table I. Interruption of Charging Current at 220 Kv on a Direc Grounded System

Line Length, Kilometers	Number of Tests	Number of Restrikes	With Nonlinear Resistors	Number of Series Breaks	$k=\frac{\sqrt{3}\,E_{\max}}{220\sqrt{2}}$ Bus (Mag)*	Bus (CRO)†	Line (Mag)	Across Circuit Breake (Mag)	Across Circuit Breake (CRC
72	8	None	No	4	1.5	1.7	1.0	1.9	1.5
72	1	One	No	4	2.4		2.4		2.2
72	1	Repeated	No	3	2.2	2.4	2.2		
72	1	None	Yes	3	1.1		1.0		
239	4	None	No	4	1.3		1.0		1.4
239	1	One	No	4	2.0		2.0		2.1
239	5	None	Yes	4	1.2		1.1		1.3
480	5	None	No	4	1.3		1.1		1.5
480	2	None	Yes	4	1.2		1.0		1.3
157	5	None	No	4	1.5		1.0		1.7

* Mag signifies data from magnetic oscillograms.

† CRO signifies data from cathode-ray oscillograms.

L. R. Bergström is with Allmänna Svenska Elektriska Aktiebolaget, Ludvika, Sweden, and **U. Sandström** is with the Swedish State Power Board, Stockholm, Sweden.



ure 1. Air-blast circuit breaker used for the test; it has six series-connected power breaks and an isolating switch

The risk of restriking in the circuit breaker depends on e magnitude of the voltage which appears across the ntacts subsequent to breaking. This voltage usually aches its peak value one-half cycle after completed interption, and represents the sum of the d-c line voltage and e crest value of the bus voltage (see Figure 2). Stations th low power output will have a large station impedance, th the result that the rise in voltage caused by the pacitive charging current will be high, and the longer e power line the greater will be the charging current and o the inductance voltage. The circuit having been oken, the capacitive current disappears, and on the bus ere will be a voltage drop corresponding to the earlier luctance voltage. With a fixed line voltage, as in the se of these tests (220 kv), the voltage across the contacts ll be lower after interruption if the line is long.

With the type of air-blast circuit breaker used in these its, maximum contact clearance is obtained about one-lf period (at 50 cycles per second) after the contact ovement has been initiated, which means that the electric strength of the circuit breaker does not continue increase beyond that point but remains practically connt. It follows, therefore, that if restriking occurs one-lf period subsequent to interruption, then the arc will strike each time the same voltage reoccurs between the ntacts. (As flashovers in compressed air usually exhibit nsiderable scattering, it is more correct to speak about e same probability of restriking at this voltage. In the ticle it has been assumed, however, that restriking will cur as soon as this voltage is attained.)

Figures 2*C* and *D* show the shape of the voltage waves after restriking. The initial circuit interruption takes place at t_1, when the line is left charged with a voltage which equals the crest value of the phase voltage prior to interruption. The bus voltage drops, owing to the disappearance of the voltage rise in the series inductive reactance. At t_2 the voltage across the circuit breaker attains its maximum value, and restriking is assumed to take place at that instant. The line and the station then are reconnected by the arc in the circuit breaker and a transient oscillation is set up, the frequency of which can be calculated with considerable exactitude from the station inductance and the zero-phase-sequence capacitance of the line. The transient oscillation is superimposed on the system frequency voltage, which returns to the original condition after reconnection of line and station by the arc.

The circuit shown in Figure 2*B* is so chosen that the transient oscillation will have a frequency equal to twice the service frequency. It is assumed that there is a certain amount of damping. Each time a voltage maximum is reached, the transient current passes through zero and consequently conditions are once more favorable for renewed interruption. As the voltage across the circuit breaker at the first of these current zeros will be greater than the restriking voltage E_a, it is nevertheless impossible to effect this interruption. The fact is that just after the current is extinguished, the bus voltage swings back to the generator voltage in a high-frequency oscillation deter-

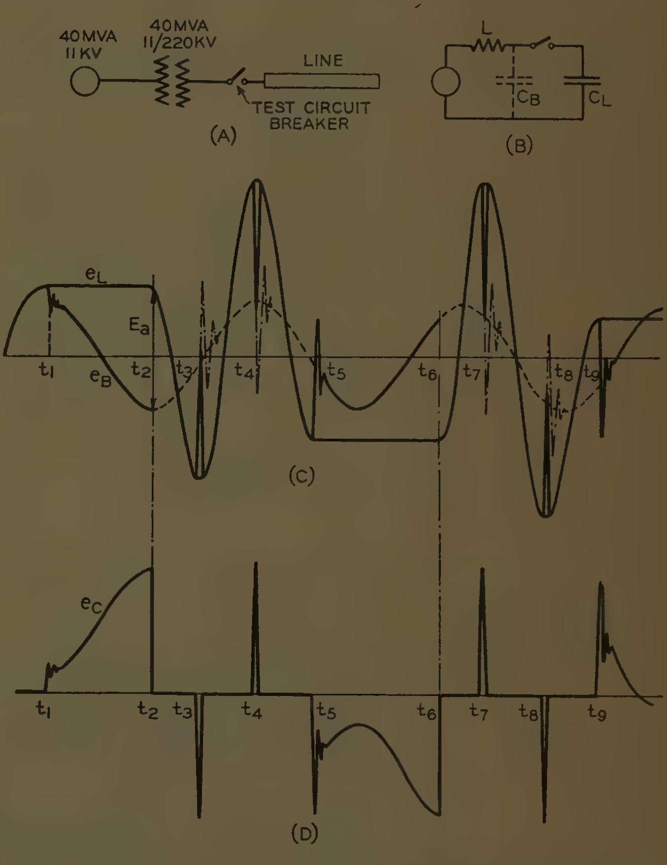


Figure 2. The shape of the voltage waves after restriking. (A). Schematic diagram of the test circuit. (B). Substitute circuit with the line represented by its capacitance. (C). Line voltage e_L and bus voltage e_B. (D). Voltage e_C across the circuit breaker. Restrikes occur at t_2, t_3, t_4, t_6, t_7, and t_8

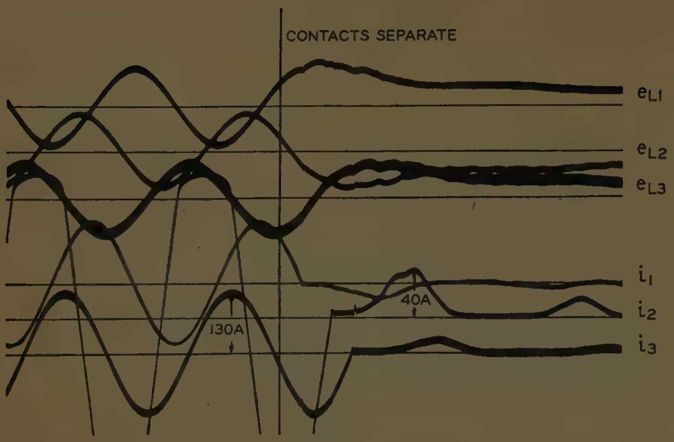


Figure 3. Oscillogram showing interruption of a 480-kilometer line; the circuit breaker is equipped with nonlinear damping resistors; e_{L1}, e_{L2}, and e_{L3} are the line voltages to ground (each 127 kv rms); i_1, i_2, and i_3 are the phase currents. After interruption i_1, i_2, and i_3 show the currents in the resistors. The record of the second phase is magnified

mined by L and C_B, while the line voltage remains at the peak value.

During this transient cycle the voltage across the circuit breaker will be too high to render the attempted interruptions successful, and the circuit can only be effectively broken when the voltage has been reduced sufficiently by damping. In Figure 2 the damping has had the necessary effect by the time the third current zero is reached; at that point the circuit breaker is once more able to interrupt the circuit. This circuit interruption, however, leads to a direct voltage on the line which is somewhat greater than that obtained after the first interruption (at t_1), so that the arc is restruck when the station voltage has changed, and the voltage across the circuit breaker once more attains the restriking value E_a. The circuit breaker is not able to interrupt the current during this restriking cycle until the third current zero is reached. The line voltage subsequent to this final circuit interruption then will be lower than after the first interruption, so that no more restriking occurs.

While it is true that Figure 2 represents a special case, it will still serve as an example from which conclusions can be drawn which are generally applicable. As restriking may always be expected to take place when the voltage across the circuit breaker attains the value E_a, there is no danger of the voltage piling up to excessive values, such as may be the case with an oil circuit breaker which is characterized by an ascending dielectric strength. In the case of an air-blast circuit breaker, the highest line and station voltages will be experienced when the restriking cycle possesses high frequency and little damping, and restriking takes place when the bus voltage is at a maximum. The peak voltage will, therefore, be nearly three times the amplitude of the phase voltage.

However, it must be realized that some time may elapse before definite interruption can take place, and therefore it is naturally preferable if all restriking can be avoided. The danger of restriking may be avoided by connecting in nonlinear resistors across the series breaks, as was done in the course of these tests. The resistors consisted, for each phase, of four porcelain elements 0.5 meter high containing 29 ceramic blocks with a diameter of 7 millimeters and height of 60 millimeters. The exponen was about 5 and the resistance at 200 kv was 20×10 ohms. Figure 3 shows how the interruption cycle i affected by these resistors.

The tests revealed that nonlinear resistors were capabl of discharging the line so rapidly that one-half cycle afte interruption the line voltage had fallen well below th critical value, even in the case of the longest lines tested As these resistors are connected across the series breaks an in series with the isolators, it was also necessary to investigat whether the latter were able to break the current flowin through the resistors. It was shown that this current wa interrupted about 2.5 cycles after the isolators had begu to open.

Table I gives the maximum k value obtained in th course of these tests, that is, the relation between the pea voltage value in any phase and the amplitude of the voltag to neutral prior to interruption. The highest overvoltag has a k value of 2.4.

IMPEDANCE-GROUNDED SYSTEM (PETERSEN COIL)

FIGURE 5*A* depicts a diagram of the test circuit. I these tests all six series breaks were connected i and, as in previous tests, these were carried out in thre phases at a line voltage of 220 kv and a frequency of 5 cycles per second. Certain tests were made with a ground

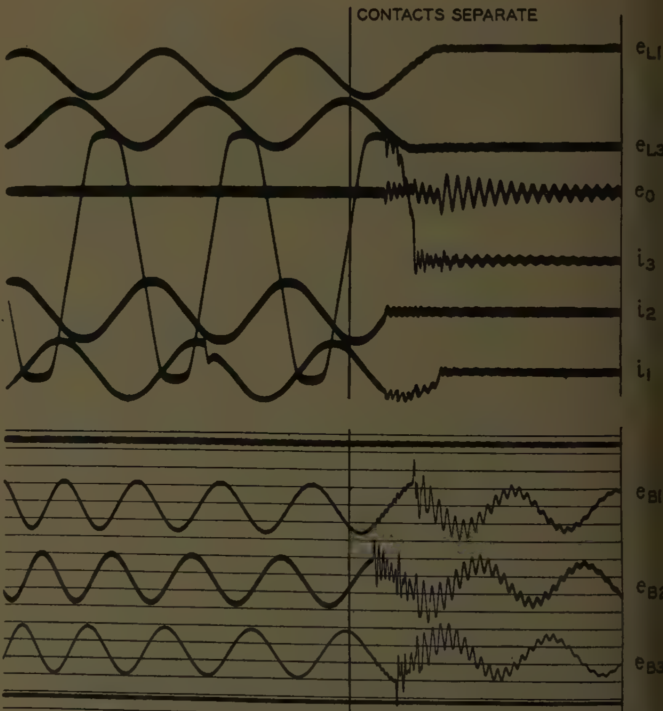


Figure 4. Oscillograms showing interruption of a 138-kilomete line, system neutral grounded with Petersen coil. The lin voltages to earth in phases 1 and 3 are e_{L1} and e_{L3} (each 12 kv rms); the voltage across the Petersen coil is e_0 and has the sam calibration as e_{L1}. The currents in the three phases are i_1, i_2, an i_3 and are all 52 amperes rms before interruption (the record o i_3 is magnified). The bus voltages e_{B1}, e_{B2}, and e_{B3} are 127 kv rm before interruption

Table II. Interruption of Charging Current at 220 Kv for an Impedance-Grounded System with Six Series Breaks

$k = \frac{\sqrt{3}\,E_{max}}{220\,\sqrt{2}}$

Line ength, ometers	Number of Tests	Number of Restrikes	With Nonlinear Resistors	With Ground Fault	Bus (Mag)*	Bus (CRO)†	Line (Mag)	Across Circuit Breaker (CRO)	Remarks
138	3	No	No	No	2.4	2.1	1.0	2.3	Petersen coil 250 amperes overcompensated
138	2	No	Yes	No	2.0	1.8	1.0	1.3	
138	6	No	No	Yes	3.6	3.2	1.8	3.1	
138	1	Repeated	No	Yes	3.7	3.8	3.1	3.8	
138	1	No	No	Yes	2.8	2.7	1.8	3.0	Petersen coil + resistance
138	2	No	Yes	Yes	2.3	2.3	1.8	1.6	Petersen coil 250 amperes
138	2	No	No	No	2.7	2.6	1.3	1.8	Free neutral
318	3	No	No	No	1.9	1.9	1.0	2.4	Petersen coil 279 amperes compensated
318	2	No	Yes	No	1.7	1.7	1.0	1.3	
318	3	No	No	Yes	2.4	2.4	2.0	2.9	
318	2	No	Yes	Yes	2.4	2.4	1.9	1.6	
318	4	No	No	Yes	2.4	2.4	1.9	3.0	Petersen coil 250 amperes undercompensated (53 cycles per second frequency)
318	2	No	Yes	Yes	2.4	2.4	1.9	1.7	

ag signifies data from magnetic oscillograms.

RO signifies data from cathode-ray oscillograms.

lt in one phase, and the effect of nonlinear damping sistors also was investigated. Restriking occurred in ly one of the 33 tests conducted (see Table II).

In a system which is grounded through an impedance, e voltage across the circuit breaker is influenced by more ctors than in the case of a direct-grounded neutral.

Interruption of an unloaded power line with neutral ounded through an impedance is characterized by an cillation in the neutral point (Figure 4). This oscillation, ich naturally affects all three phases, serves partly to crease the overvoltage at the instant of interruption, and so serves to raise the voltage one-half period after interption, when the risk for restriking is greatest. Most verely affected is the phase to be extinguished first, as e voltage across the circuit breaker in this phase at the stant of extinguishing the final phase will be close to the rmal amplitude value, and the neutral point oscillation ll have been only slightly damped before the voltage aximum is reached.

Figure 5*B* shows voltage waves obtained from the test rcuit of Figure 5*A*. In phases 1 and 3 restriking has curred almost simultaneously. Restriking occurs in ase 3 because the arc restriking in phase 1 causes a ltage surge with a magnitude equal to the voltage across e circuit breaker in phase 1 at the instant of restriking. his surge travels into the transformer and sets up an cillation with great amplitude in the neutral point. This cillation also influences the voltage of the other two ases. The voltage in phase 3 becomes excessive, and the c restrikes in this phase. The appearance of this oscillaon in the two phases when a restrike occurs only in one ase is shown in Figure 5*C*. In this case the voltage across e circuit breaker just before restriking is only 350 kv ome of the circuit-breaker elements were not in function), t the voltage to earth in phase 2 becomes as high as 600 . This indicates that a restrike in one phase of an pedance-grounded system may cause dangerously high ervoltages on the supplying transformer.

As in the previous tests, the damping resistors materially wer the overvoltages, and, by discharging the line, reduce e voltage one-half period after interruption to values which are safely below the restriking voltage. The current flowing at the instant of opening the isolators was less than 10 amperes maximum in all the tests, and the arcing time of the isolators was the same as for the direct-grounded system. Results of the tests are given in Table II. The highest overvoltage has a *k* value of 3.8 and is obtained with the 138-kilometer line and with a ground fault in one phase; the only restriking occurred in this test. With nonlinear resistor the highest overvoltage has a *k* value of 2.4.

INTERRUPTION OF SHUNT REACTOR LOAD

Figures 6*A*, *B*, and *C* represent the simplified diagrams of connections used to investigate different service conditions. Protection for the plant was provided in the

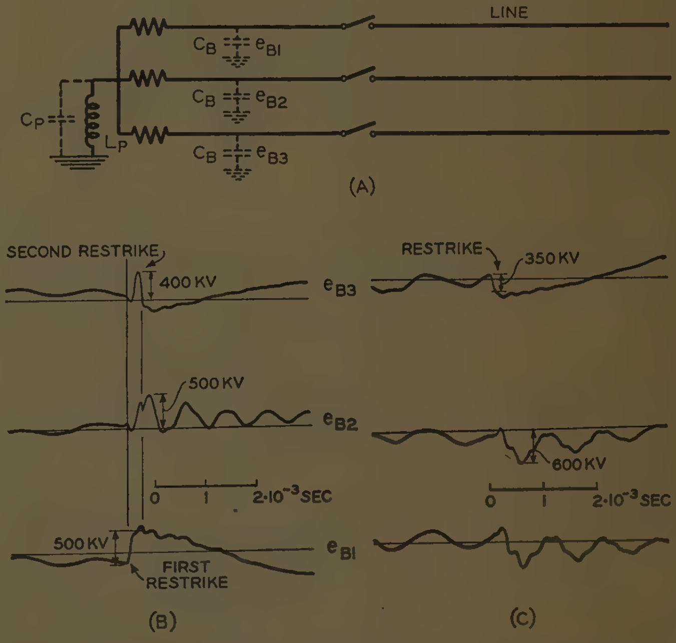


Figure 5. Test of the bus voltage when restriking occurs in a 138-kilometer line with the system neutral grounded with a Petersen coil. (A). Test circuit; phase 2 was grounded on the line side of the circuit breaker. (B). Cathode-ray oscillogram showing a restrike in phase 1 and almost simultaneously a restrike in phase 3. (C). Restrike in phase 3 and oscillations with high amplitude in the other two phases

Table III. Interruption of Reactor Current at 220 Kv

Inductance on Reactor Side, Henrys	Number of Tests	Number of Series Breaks	With Nonlinear Resistors	Reactor Current, Amperes	$K=\frac{\sqrt{3}E_{max}}{220\sqrt{2}}$				Remarks
					Bus (Mag)*	Reactor Side (Mag)	Reactor Side (CRO)†	Across Circuit Breaker (CRO)	
16.8	8	4	No	23	2.2	2.6	2.6	2.7	Connection Figure 6
6.0	4	4	No	63	1.5	1.9	1.8	2.5	
16.8	2	4	Yes	23	1.0	1.8	1.8	1.0	Connection Figure 6
6.0	2	4	Yes	64	1.1	1.7	1.7	1.1	
16.8	2	4	No	23	1.0	3.5‡		3.3	Connection Figure 6
16.8	2	4	Yes	23	1.0	2.0	2.0	1.0	
16.8	2	6	No	25	1.0	3.2	3.4‡	4.5	Connection Figure 6
16.8	1	6	Yes	25	1.0	1.9		1.0	

* Mag signifies data from magnetic oscillograms.

† CRO signifies data from cathode-ray oscillograms.

‡ Flashover in rod gap.

form of rod gaps, set to 630 kv, and connected on the reactor and station side. For these tests, which were carried out at about 220 kv, two values of shunt reactor inductance were employed, which when translated to the high-voltage side represented 16.8 and 6.0 henrys. These reactor values and the station inductance give currents of 24 and 65 amperes rms. Interruption of the heavier current did not produce any serious overvoltages, which is explained partly by the fact that the forced interruption does not result in an abrupt cutting off, and partly by the lower inductance which signifies a correspondingly lower energy content at the instant of forcing.

From the oscillograms it is possible to determine the current values at which forced interruption takes place, that is to say, the current value at which the current begins to depart from the sinusoidal shape and commences to fall, more or less steeply, towards zero. This current value is found to be identical for most of the tests, 10 to 15 amperes maximum, with the exception of those instances when a power line has been connected to the station. In the latter case the arc has been unstable at a comparatively high current value.

Forced interruption in tests carried out with direct-grounded neutral (Figure 6A). Four circuit-breaker elements employed. The overvoltages when interrupting the first phase will be very low because of the low inductance in the zero-sequence network. Interruption in the second phase is very difficult to analyze owing to the complicated connection of the networks. The oscillograms usually indicate lower overvoltages in this phase than in the one finally extinguished.

When analyzing the third phase to clear one can find that the highest overvoltages arise from the sequence networks which contain the reactor inductance. The highest overvoltage (see Table III) obtained in this case was $k=2.6$.

Forced interruption in tests with direct-grounded neutral and a 40-kilometer line connected to the bus (Figure 6B). Four circuit-breaker elements employed. Owing to the small inductance of the zero-sequence network in the first phase to clear, the overvoltages produced at forced interruption will be low as in the previous case.

When interruption takes place in the third phase th capacitances of the station and reactor sides are connecte across the arc, and when there is no line connected to th bus the two capacitances will be about equal. When line is connected to the bus, the capacitance of the latte increases to several times that of the reactor side, and th resultant capacitance in parallel with the arc will be greate than in the first case. Increased parallel capacitanc across the arc facilitates forced interruption and serves t make the arc unstable at high current values.

The oscillogram in Figure 7 (bus side) indicates that a attempt at forced interruption has occurred in the thir phase to clear, but that the current did not at first fall t

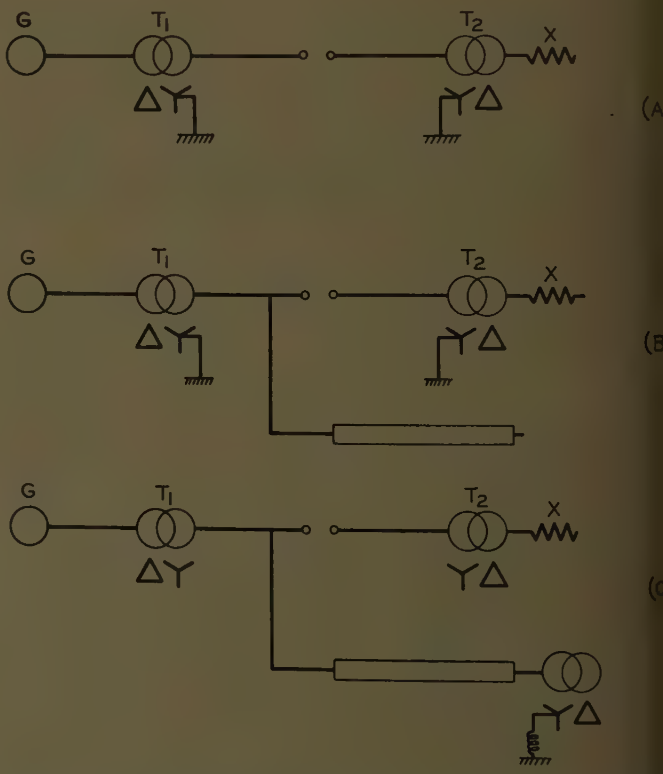
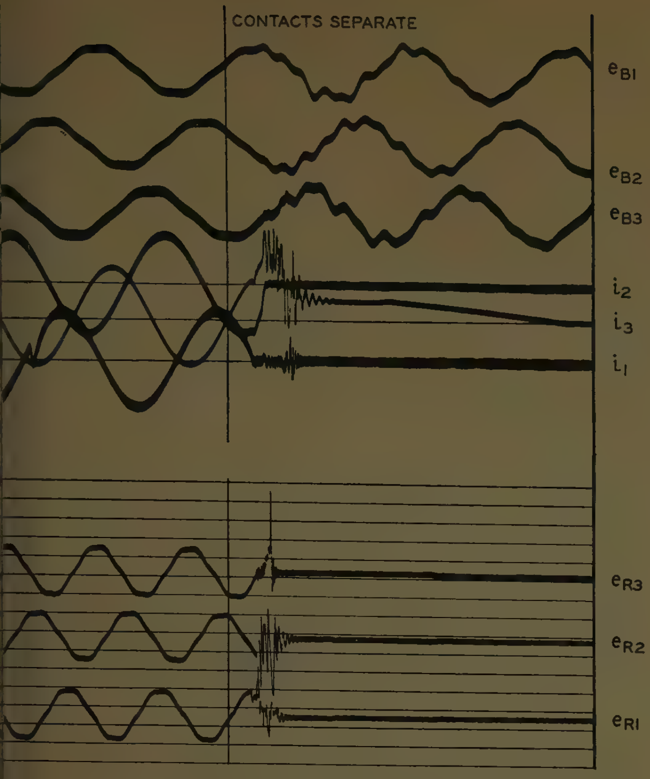


Figure 6. Connections at the shunt reactor tests. Generator rated 40 megavolt-amperes, 11 kv; transformer T_1 rated megavolt-amperes, 11/220 kv; transformer T_2 rated 60 megavol amperes, 11/220 kv; reactor X rated 10 and 30 megavolt-ampere (A). The neutrals of T_1 and T_2 grounded. (B). 40-kilomete line connected to the bus. (C). 138-kilometer line connecte to the bus; the neutrals of T_1 and T_2 isolated



**ure 7. Oscillograms showing interruption of reactor load (test
nection Figure 6A); e_{B1}, e_{B2}, and e_{B3} are the bus voltages to
ound (120 kv rms before interruption); i_1, i_2, and i_3 are the
ctor currents (23 amperes rms). The direct current i_3 depends
a flashover in the protection gap. The reactor voltages are
e_{R1}, e_{R2}, and e_{R3}**

o. It was only after several attempts had been made
t the current went down to zero, and then it was accom-
nied by overvoltages so high that an arc was struck
oss the protecting gap, thereby effectively discharging
magnetic energy stored on the reactor side.

From the test results in Table III it appears that the
gest k value is 3.5, but this value is limited by the pro-
tion gaps.

*Forced interruption in tests carried out with free neutral (capaci-
connected to neutral) and with a 138-kilometer line connected
he station (Figure 6C). Six circuit-breaker elements employed.*
e tests were carried out with isolated neutral in both
nsformers and with a power line connected to the station,
latter being connected to another transformer at the
her end with a neutral grounded via a Petersen coil.
th transformer neutrals were equipped with overvoltage
otection consisting of an 18,000-micromicrofarad capaci-
on the reactor side. In this case also the first phase to
ar will give rise to high overvoltages, as the zero-se-
ence network will have a considerable impedance.

Because of the large capacitances connected in parallel
th the arc, forced interruption can be carried out at
mparatively heavy current, as in the previous case. On
reactor side the voltage is usually not limited by the
lectric strength of the circuit breaker, as the maximum
ltage on the reactor side occurs at the first peak of the
illation, whereas the maximum voltage stress on the
cuit breaker occurs at the second peak. Therefore, it is
quite possible for flashover to take place on the reactor side without the strength of the circuit breaker having been exceeded.

In this case the largest k value is 3.4 for the reactor side and 4.5 across the circuit breaker (see Table III). As in the previous case, the overvoltages on the reactor side are limited by the protection gaps.

The damping resistors serve materially to reduce the overvoltages in these tests also. Table III shows that the maximum k value is reduced to 2.0. The arcing time of the isolators in the tests with direct-grounded neutral was about the same as in the former tests. In the tests with free neutral the arcing time of the isolators was a little longer, but no difficulty was experienced in interrupting the resistor current.

RESULTS APPLIED TO THE 380-KV NETWORK

THE TESTS carried out with a direct-neutral were so devised that the results should be applicable to the 380-kv system. However, they will also be useful in the solving of the problems arising in connection with the Swedish 220-kv system, which is at present grounded through Petersen coils, but which will be direct-grounded in the near future.

Figure 8 shows the wiring diagram of the single-power-line 380-kv system in the first stage of completion. In this stage there will be the most difficult case of circuit breaking with an off-load power line. As described in a report of the International Conference on Large Electric High-Tension Systems,[2] there will be a powerful rise in

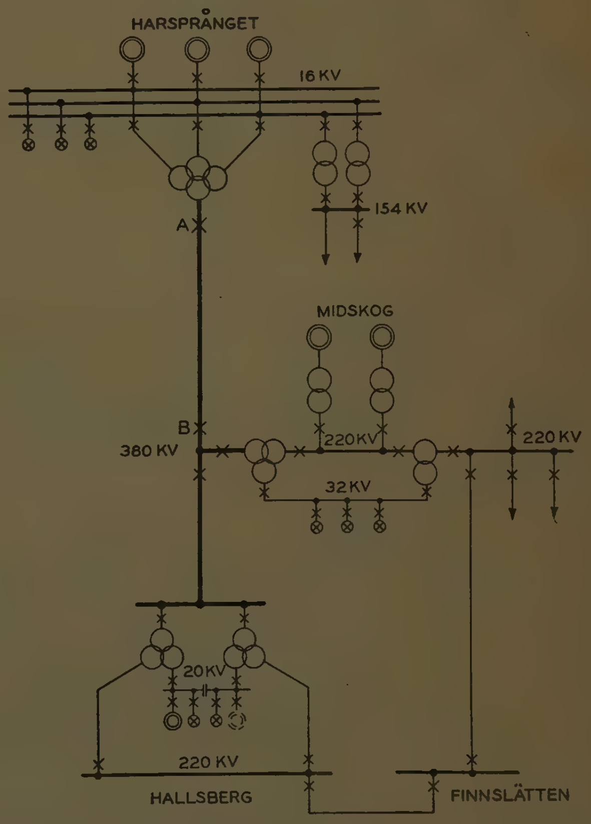


Figure 8. Line diagram showing the first stage of the Swedish 380-kv system

voltage in the first moment after a tripping of circuit breaker *B*, when the Harsprånget generators are running at full load. With one of the Harsprånget generators in operation and at a line voltage of 370 kv, the line will be subjected to a voltage of 585 kv at Harsprånget and 670 kv at Midskog subsequent to circuit breaker *B* tripping. If circuit breaker *A* is required to trip after *B* but before the automatic generator regulation has had time to take effect, it will be a rather severe case of breaking, as the voltage at circuit breaker *A* prior to interruption is 155 per cent of the service voltage. The purpose of these tests has been to simulate these conditions and similar cases of excessive voltages across the power breaks by reducing the number of breaks employed in the test.

The highest overvoltage factor experienced on the bus side of the circuit breaker was 2.4 with restriking and 1.3 without restriking for the longest line and 1.7 for the shortest line. These are the values obtained without the use of damping resistors. With damping resistors *k* was 1.2 for all line lengths. With a *k* value of 2.4, restriking in this case would produce an overvoltage having a peak voltage of 1,150 kv.

The interruption tests with reactor-loaded transformers have shown that in this case even higher overvoltages may arise, especially if an unloaded line is connected to the bus side of the circuit breaker. Without damping resistors the *k* value measured 3.5, but in this case the overvoltage wa limited by the spark gap. With damping resistors th highest *k* value amounted to 2.0.

As it is not desirable for the surge diverters to ignite fo switching overvoltages, the permissible *k* values will b decided by the sparkover voltage of the diverters. Spark over due to switching overvoltages will take place a about the same value as for 50 cycles per second. For th 380-kv diverter this means about 720 kv, correspondin to an amplitude of 1,020 kv. At a line voltage of 380 k prior to interruption this corresponds to a *k* value of 3. and at 585 kv prior to interruption *k* is 2.2.

The comparison between these values and those obtaine for tests carried out with and without damping resistor indicates that a 380-kv air-blast circuit breaker which i required to interrupt a reactor load requires such dampin resistors. The need is not equally great in the case c line circuit breakers, but from the point of view of ensurin service reliability of the system, and in view of the lo additional cost, it is desirable that all line circuit breaker should be provided with damping resistors.

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Application of the Information Theory to System Design

W. G. TULLER

The general principles of the application of information theory to system design is discussed here, and an example is given showing its use in studying the Private Line Air Traffic Control Communication System.

THE STATISTICAL theory of communications, developed over the past few years and quite often called information theory, can be of real assistance in the design of communication systems. Although very little can be obtained in system performance by the use of this theory that could not have been predicted by earlier methods, the theory provides a logical and straightforward method of evaluating a communications problem and tells directly the effect o necessary compromises from the ideal in bandwidth power, rate of transmission o information, and so forth

In this article a short genera discussion of the method will be followed by a practica example of a communication system that has been de signed in accordance with the method. This is the interim "Private Line" communication link between the airpor traffic controller and the aircraft which is under his sur veillance.

DESIGN PRINCIPLES

A PRELIMINARY STATEMENT of the method of system design is deceptively simple. One merely com putes the maximum rate at which information must b

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W. G. Tuller is with Melpar, Inc., Alexandria, Va.

Although the author served on Special Committee *41* of the Radio Technical Committee for Aeronautics, the material in this article is primarily the work of a large group on this committee; members of the committee are too numerous to name individually. The evaluation was a group effort under the guidance of Vernon C. Weihe.

ansmitted in units of bits or Hartleys* per second.
he available bandwidth and carrier-to-noise ratio then
e used to determine the maximum rate at which in-
rmation may be transmitted over the facilities available.
the second quantity is greater than the first, the system
esigner is indeed fortunate; the information may be
ansmitted over the transmission link, and the problem is
duced to one of inserting a controlled redundancy into
e message to improve transmission clarity. If the
cilities are inadequate to the task, then the designer
ust strive either to obtain more facilities, that is, band-
idth, power, and sensitivity, or he must wring some
dundancy from his message if he does not give up entirely.
n either event a straightforward calculation yields an
nmediate answer as to the possibility of accomplishing
e desired task with the available equipment and spec-
um. If, by any chance, either transmitter power, re-
eiver sensitivity, or transmission bandwidth are under
e complete control of the system designer, then he may
hoose one of these in order to allow transmission of his in-
rmation at the required rate. Usually, however, this is
ot the case.

The equations used to determine the information content
the set of possible messages and the information handling
apacity of the system are well known[1,2] but they will be
epeated here for completeness.

To find the information content of the set of messages
at may be transmitted one uses the expression

$$'=n' \log_{10} s \qquad (1)$$

$_1'$ is the rate of information output of the message source
Hartleys per second where s is the number of possible
qually likely significant values (the case where the values
e not equally probable is taken up by Dr. Shannon,[1]
ut is of practical use only when complex coding is per-
issible) which the message may have at any given time,
d n is the number of times per second a value must be
osen in order not to lose information. If the message is
the form of an electric signal, and has no redundancy,
at is, its future may not be guessed with significant ac-
uracy from *a priori* knowledge or from the past history of
e message, we have

$$=1+S/N \qquad (2)$$

here S/N is the signal-to-error (noise) ratio at the input
the modulator in the generalized communication system
own in Figure 1. S/N must also be the signal-to-error
oise) ratio at the output of the demodulator in this
stem if no information is to be lost.

Said in another way, from the viewpoint of the in-
rmation source, s is the number of symbols that could
ave been emitted at any instant of time. Of this ensemble,
ne will be emitted n' times per second. This relation
efines n' in equation 1.

In electrical terms we have

$$=2f_c \qquad (3)$$

where f_c is the premodulation and post demodulation bandwidth of the system shown in Figure 1. The coder and decoder of Figure 1 may be used to remove and/or insert redundancy into the message as desired.

To determine if facilities are adequate for the information source the following equation is used:

$$H_2'=2B \log_{10}(1+C/N) \qquad (4)$$

Here H_2' is the information handling capacity of the transmission link, B is the bandwidth of the elements between modulator and demodulator, and C/N the carrier-to-noise ratio at the input to the demodulator.

If H_2' is greater than H_1' the system is adequate to handle the demands of the source of information. If not, as has been mentioned, something must be done to either the information or the communication equipment.

APPLICATION TO AIR TRAFFIC CONTROL

To go to a practical example, Special Committee *41* of the Radio Technical Committee for Aeronautics had as its task an operational and technical evaluation of a Transition Period Air Traffic Control Communication System, a private line between the air traffic controller and each aircraft under his control. The purpose of such a system is to provide more rapid exchange of messages between a ground station and each aircraft on an individual communication link than can be done by radio telephone. The evaluation was done by *SC41* using information theory, and the techniques which were used in the evaluation of the ground-air link are given in the following paragraphs.

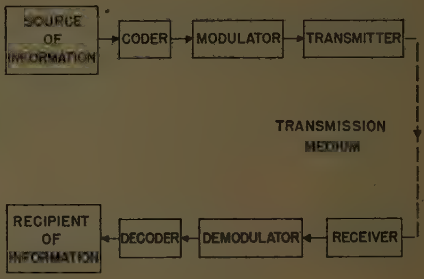

Figure 1. A block diagram of generalized communications systems

Available for this communication system is the band of audio frequencies between 5,000 and 7,000 cycles. This band lies between the voice channel and the subcarrier used in the very-high-frequency omnidirectional radio range (VOR) equipment. It is available on VOR, very-high-frequency (VHF) localizers, and VHF Tower and VHF Enroute Communication Transmitters. This band is also available in the standard VHF Navigation Receiver.

Thus, if this audio band could be used, no new radio equipment would have to be added on the aircraft or on the ground to perform the private line function. Only terminal equipment would be required. Inasmuch as the radio-frequency carriers may be modulated by other subcarriers, only 15-per cent modulation is available for private lines. This means the system must operate well with a minimum carrier-to-noise ratio.

Bit is defined as a unit of information capacity, equal to one binary decision, or the
signation of one of two possible values or states of anything used to store or convey
formation. Hartley is defined as a unit of information capacity, equal to one decimal
cision, or the designation of one of ten possible values or states of anything used to store
convey information.

Substituting bandwidth and minimum carrier-to-noise ratio in equation 4

$$H_2' = (2)(2000) \log (1+1) \tag{5}$$

Since C/N must be assumed a minimum of unity (actually rms carrier-to-noise ratio must be eight decibels to obtain a peak carrier-to-noise ratio of unity) it is convenient to take H_2' in bits per second and use a logarithm to the base 2. This gives

$$H_2' = 4000 \text{ bits per second} \tag{6}$$

as the capacity of the equipment. The remainder of the system design comprised an attempt to force the information source to fit this mold. By the use of visual presentation to the pilot and automatic or key-punch message selection, a predetermined group of messages may be used and one chosen and presented efficiently.

As a result of considerable work by the operational group, the messages to be presented, and their display, were chosen as shown in Figure 2. In this figure the possible messages that may appear in each position are shown in tabular form beneath the rectangle depicting the slot through which the message appears. Circles indicate buttons to be pressed by the pilot to tell the controller that he is acting on instructions (corresponding to "Wilco").

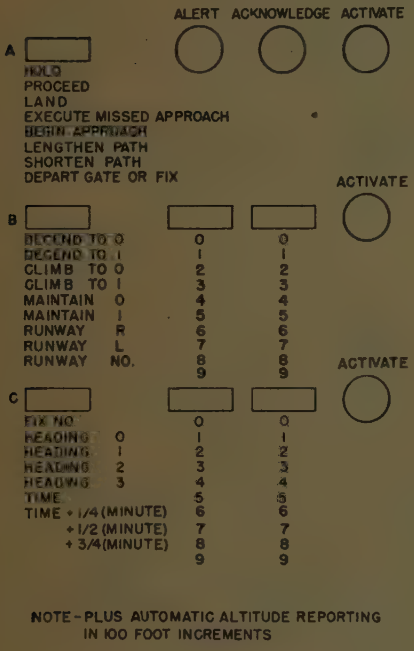

Figure 2. Information to be presented by cockpit display

From Figure 2 it may be seen that a complete ground-to-air message comprises seven "words" and that each word has a maximum of ten possible choices or values. This sets s in equation 1 as ten. Since transmission must be in binary code to operate at minimum carrier-to-noise ratio, s was fixed at 16, the nearest larger power of two, or 2^4, with a resultant possibility of an increased number of messages or a safety code (one employing redundancy) should it be desired. From Figure 2 we also obtain n as seven words per unit of time in which an aircraft must be contacted.

Operationally it was determined that each of at least 15 aircraft should be contacted every five seconds, and that at least 60 assignable aircraft identities should be available. The aircraft identity, which makes the private line private, therefore requires two more words.

Summing up, nine words per aircraft must be transmitted in 5/15 or 1/3 second. This means a rate of 27 words per second. Each word has a content of four bits, since 16 choices are available. The information handling capacity required of the system is therefore 108 bits per second.

Comparing the required capacity of 108 bits per second with the available capacity of 4,000 bits per second, we see that ample system information handling capacity is available. Since equation 4 is based on the use of ideal filters, a conservative design would only attempt to obtain 2,000 bits per second.

USE OF EXCESS CHANNEL CAPACITY

SINCE the available channel capacity is so much greater than required, it was recommended that controlled redundancy be introduced in the form of a self-checking code. If a word is sent once in the marks and once in the spaces of a code group, it is immediately apparent if an error has been made. This safety coding requires a capacity of 162 bits per second. The additional capacity still available may be used to obtain improved operation at low carrier-to-noise ratios or to contact more aircraft per second. In practice, some capacity must also be used up in this particular system to allow for transmission lag through the link and to allow for a "Screen Lift" signal, not previously mentioned, that assures the pilot his instructions have been checked on the ground, after retransmission from plane to ground, and found accurate. Inasmuch as the private line is to be operated in conjunction with the phase- and interference-sensitive VOR circuits, it was thought that the remaining additional capacity would best be used in protecting these circuits and in obtaining improved performance at low signal levels.

RESULTS OF ANALYSIS

THE PRELIMINARY analysis given in the foregoing ensured that a conservative system design could be obtained, and that the necessary equipment design would be a straightforward problem. From this analysis it was possible to proceed with confidence to a consideration of specific equipment.

The example given illustrates certain basic principles worthy of special note. These are the calculation of system information handling capacity and information source output, the use of a coding scheme exactly fitted to the limited information which is to be transmitted, and controlled redundancy in order to obtain improved system reliability.

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Loci of Complex Impedance and Admittance Functions

E. L. MICHAELS
ASSOCIATE AIEE

CURVES OF impedance and admittance in the complex plane for various combinations of 2-terminal -element linear dissipative networks are extremely useful n the solution of many electrical engineering problems ecause of the direct, straightforward manner in which hey show graphically the resistive and reactive comonents of complex impedance and admittance, the agnitude of impedance and admittance, and the phase hift at all frequencies between zero and infinity. The urves also reveal that the 16 possible combinations of 2-erminal 3-element networks fall into four main groups of our networks each.

One of the main groups of four networks is shown in igure 1. In each of the four plots of Figure 1, the real nd imaginary components of complex impedance in ormalized form are plotted along the real and imaginary xes of the complex impedance plane. A nonuniformly istributed scale of normalized frequency F/F_0 exists along he K curves of each plot. In the cases where K curves ppear in their entirety, the entire range of frequencies is overed, from zero to infinity. From the information given bout F/F_0 and K for each network, it is readily apparent hat the impedance of each network may be found graphially at any frequency in either complex or polar form.

Important concepts involving relationships among the our networks of each group are those of inverse, reciprocal, nd equivalent networks. The first important concept is hat of inverse networks. Two networks with impedances Z_1 and Z_2 are each the inverse of the other with respect o a real constant R if:

1. The impedances satisfy the relation $Z_1Z_2=R^2$.
2. Corresponding elements are related by $L/C=R^2$.
3. Elements in series in the given network appear as nverse elements in parallel in the inverse network, and ice versa.

The second concept deals with reciprocal networks. Two networks are the reciprocal of each other if:

1. The impedance of one is the conjugate of the impedance of the other.
2. The normalized frequency of one is the reciprocal f that of the other.
3. Corresponding elements are related by $L/C=R^2$.
4. Elements in series in the given network appear as nverse elements located also in series in the reciprocal etwork, and similarly for elements in parallel.

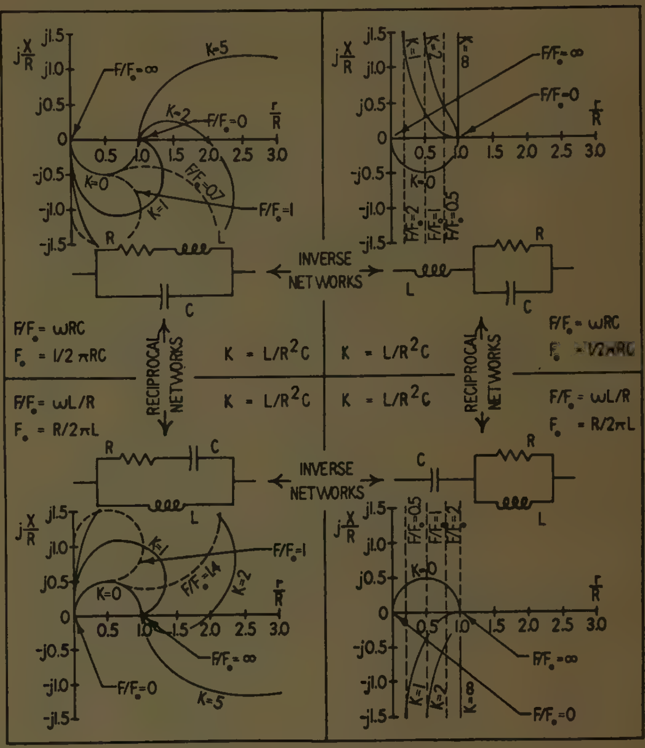

Figure 1. Normalized complex impedance curves for one group of 2-terminal 3-element networks

The third concept, which does not apply to the group of etworks in Figure 1 but does apply to other groups, concerns equivalent networks. Two networks are equivalent if:

1. The impedance of one is equal to the impedance of the other at corresponding frequencies.
2. Elements in series in the given network appear as elements of the same type in parallel in the equivalent network, and vice versa.

In one application a wide-band amplifier was designed to have a variation in gain from the mid-band value of less than 0.2 decibel and a phase shift of less than 25 degrees between 5 cycles and 4.5 megacycles. A high- and low-frequency compensation network was designed with the use of these types of curves.

The curves of normalized impedance and admittance plotted in the complex plane for 2-terminal 3-element networks are particularly useful because of the wealth of information they contain. Network behavior is shown more completely and directly than by any other type of plot. The curves are especially useful in determining the most useful frequencies for accurate calculations and in readily showing the frequency ranges in which the effects of certain elements may be neglected.

The number of possible applications is unlimited. As familiarity with the curves is gained many specific applications suggest themselves.

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igest of paper 51-47, "Loci of Complex Impedance and Admittance Functions," ecommended by the AIEE Committee on Basic Sciences and approved by the AIEE echnical Program Committee for presentation at the AIEE Winter General Meeting, ew York, N. Y. January 22–26, 1951. Scheduled for publication in AIEE *Transctions*, volume 70, 1951.

. L. Michaels is with The Rauland Corporation, Chicago, Ill.

Calculating Transmission-Line Load Impedance

S. G. LUTZ
MEMBER AIEE

THE ratio of sending-end to receiving-end power for a transmission line, or other 4-pole apparatus, is

$$\frac{W_s}{W_r}=\frac{E_sI_s+E_s'I_s'}{I_r^2|Z|\cos\phi} \qquad (1)$$

where I_r is the magnitude of the receiving-end current, $|Z|\cos\phi$ is the real part of the load impedance, E_s and I_s are the real parts of the sending-end voltage and current, and E_s' and I_s' are the imaginary parts of the sending-end voltage and current. By expressing these sending-end values in terms of the long-line equations, expanded into their real and imaginary parts, one eventually obtains

$$\frac{W_s}{W_r}=\frac{1}{2\cos\phi}\left[\frac{|Z_0|}{|Z|}(\sinh 2\alpha l\cos\theta-\sin 2\beta l\sin\theta)+\frac{|Z|}{|Z_0|}(\sinh 2\alpha l\cos\theta+\sin 2\beta l\sin\theta)\right]+\frac{1}{2}[(\cosh 2\alpha l+\cos 2\beta l+(\cosh 2\alpha l-\cos 2\beta l)(\cos 2\theta+\sin 2\theta\tan\phi)] \qquad (2)$$

in which $|Z_0|$ and θ are the magnitude and phase of the characteristic impedance, α is the attenuation parameter in nepers per unit line length, and β is the phase parameter in radians per unit line length. When the line is terminated in its characteristic impedance this ratio reduces to

$$\left.\frac{W_s}{W_r}\right|_{z=z_0}=\epsilon^{2\alpha l} \qquad (3)$$

which is not necessarily the lowest power ratio obtainable but which serves as a simple and useful reference.

Differentiating equation 2 with respect to $|Z/Z_0|$, equating to zero and solving, leads to

$$\frac{|Z|}{|Z_0|}=\sqrt{\frac{\sinh 2\alpha l\cos\theta-\sin 2\beta l\sin\theta}{\sinh 2\alpha l\cos\theta+\sin 2\beta l\sin\theta}} \qquad (4)$$

Since this relation is independent of the load impedance angle ϕ, it represents the best load impedance magnitude ratio irrespective of ϕ. This ratio reduces to unity for line lengths which are multiples of a quarter wave lengt at which $\sin 2\beta l=0$, and approaches unity for such larg attenuations that $\sinh 2\alpha l$ becomes much larger than unit This impedance ratio will be unity for all line lengths θ, the angle of the characteristic impedance, is zero. Th characteristic impedance of most common lines has negative angle, approaching −45 degrees for cables wit negligible inductance and leakage conductance. For suc lines the impedance magnitude ratio will be greater tha unity for lines of less than a quarter wave length, less tha unity lengths between a quarter and half wave lengt then alternately greater and less in succeeding region becoming negligible as the attenuation increases with lengt

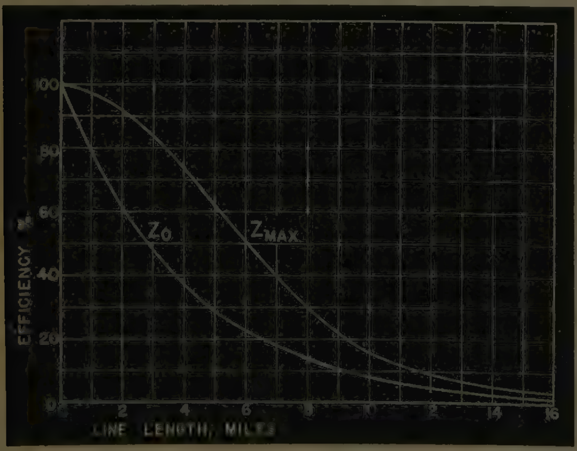

Figure 1. Impedance magnitude ratio and load impedance angle as a function of length

Differentiating equation 2 with respect to ϕ, equatir to zero, and solving, leads to

$$\phi=\sin^{-1}\frac{\sin 2\theta(\cos 2\beta l-\cosh 2\alpha l)}{\frac{|Z_0|}{|Z|}(\sinh 2\alpha l\cos\theta-\sin 2\beta l\sin\theta)+\frac{|Z|}{|Z_0|}\times(\sinh 2\alpha l\cos\theta+\sin 2\beta l\sin\theta)}$$

If differentiated again with respect to the impedan magnitude ratio, this again leads to the best ratio give by equation 4. Some additional simplification is gaine by substituting this ratio in equation 5, which then becom

$$\phi|_{Z_{\max}}=\sin^{-1}\frac{\sin 2\theta(\cos 2\beta l-\cosh 2\alpha l)}{2\sqrt{(\sinh 2\alpha l\cos\theta)^2-(\sin 2\beta l\sin\theta)^2}}$$

Here, because of the $\sin 2\theta$ factor, ϕ will be zero when θ zero, so the characteristic impedance must be the mo efficient load whenever it is a pure resistance. When is not zero the sign of ϕ should be opposite to that of but not necessarily its exact negative unless the attenuati is very large, in which case the most efficient load will the conjugate of the characteristic impedance.

Figure 1 shows the impedance magnitude ratio and loa impedance angle for maximum efficiency plotted as function of length for a 19-gauge nonloaded telephone cab operating at a frequency of 1,000 cycles. For such cable, $Z_0=470.1\underline{/-42.8}$ degrees, $\alpha+j\beta=0.1249+j0.133$ and the wave length is 46.95 miles. In this case, θ is near its limiting value of −45 degrees that the best loa becomes radically different from the characteristic i pedance for short lines. However, the attenuation is high that, beyond a quarter wave length, the best loa is the conjugate of the characteristic impedance.

Application of this analysis may be quite limited as pow transmission engineers are concerned primarily wi electrically short lines which can be studied by simpl methods based on approximately equivalent networ

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S. G. Lutz is Chairman of the Electrical Engineering Department, New York U versity, New York, N. Y.

Control of Gas Turbines for Power Generation

D. C. HOFFMANN
MEMBER AIEE

A. G. MELLOR
ASSOCIATE AIEE

N. E. STARKEY

THE DEVELOPMENT of the combustion gas turbine as a new type of prime mover for power generation as required the parallel development of suitable controls. he control being used at present on General Electric gas urbines provides for semiautomatic starting and stopping f the unit for speed and load control and for protection f the unit under abnormal conditions.

Several characteristics of gas turbines make the control roblem different from that encountered with other types f prime movers. For instance, gas turbines are not self-tarting and are not self-sustaining below about 50-per ent speed. Therefore a means must be provided to crank he unit to firing speed and to assist acceleration after ring. A temperature control must be provided to limit aximum and rate of change of turbine inlet temperature o prevent damage to the turbine. Turbines that normally perate on Bunker-*C* oil must be started on Diesel oil and ransferred to Bunker *C* at or above idle speed.

These unique characteristics of the gas turbine made it esirable to provide partial automatic control on the first ommercial gas turbine. Later designs, evolved from he first control, are more automatic and include changes o improve reliability, to prevent damage by operational rrors, and provide more protection for the gas turbine. The first application of the automatic control has been o a 3,500-kw oil-fired unit. The same basic control can e applied to other turbines and natural-gas-fired units. The following components are mounted on the turbine:

1. A unit-driven variable-displacement pump to obtain e required range of fuel flow for speed and load control. he displacement of the pump is set by a control oil ressure from the fuel regulator.
2. Fuel regulator and electric governor, an electro-ydraulic servomechanism into which are fed a speed gnal, an adjustable fuel limit, and an exhaust temperature gnal. Output of the regulator is a control oil pressure accordance with whichever of the signals requires the ast fuel flow. The speed signal is obtained from a shaft-riven tachometer generator. Speed is adjustable over a -to-1 range by a motor-driven speed-setting rheostat. he adjustable fuel limit sets the control oil pressure for arting and acceleration. The exhaust temperature signal obtained from a gas-filled bellows on the turbine exhaust od.
3. Solenoid-operated stop valve in the fuel inlet line.
4. Overspeed governor set to shut the unit down at 10-per cent speed.
5. Motor-operated fuel transfer valve.
6. Flame detectors.
7. Ignition system to initiate combustion.
8. Atomizing air compressor for fuel atomization.
9. Lubricating oil pumps. A shaft-driven pump backed up by an a-c motor-driven auxiliary pump and a d-c motor-driven emergency pump.
10. An a-c motor-driven turning gear to start the unit from rest and a wound-rotor induction motor to crank the unit to self-sustaining speed.
11. Miscellaneous pressure and temperature switches in the lubricating oil, fuel oil, and atomizing air systems.

The turbine is controlled from the main duplex control board located on the turbine room floor. Instruments, recorders, annunciator, and control switches are on the front panels; sequence and protective relays on the rear.

In an installation of this type, many conditions must be checked before the turbine can be started safely. Starting and stopping the unit includes steps that must be performed in correct sequence and at proper time intervals. Automatic control is provided to relieve the operator of most of the routine and responsibility of performing and checking each step for starting and stopping.

In designing the control, principles well established in other applications were used to full advantage. Such principles include use of station battery, selective fusing of control and trip circuits, and interlocking of sequence and timing functions to obtain maximum reliability, and safety. Protective devices are grouped so that they are selective in the manner in which the unit is shut down.

All automatic control functions are directed by a master relay that must be energized by the master control circuit before the unit can be started. The master control circuit includes protective relays and other devices that check that normal conditions exist before starting can begin.

While the actual starting sequence is automatic, the operator must first energize the control circuits, check the position of certain selector switches, and start the cooling water, fuel oil, and auxiliary lubricating oil pumps before operating the master control switch to the start position. After the sequence has progressed through the various steps required in starting and accelerating the unit, the operator must synchronize the generator and pickup load.

The normal shutdown sequence is almost all automatic. After the generator has been disconnected from the bus, operation of the master control switch to the stop position will initiate the various steps required for shutdown. Provision has been made for automatically putting the unit on turning gear for a time after shutdown to permit cooling.

A selector switch is provided to interrupt the starting sequence at several selected points for testing or to facilitate calibration of protective and control devices.

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D. C. Hoffmann is with the General Electric Company, Philadelphia, Pa., and **A. G. Mellor** and **N. E. Starkey** are with the General Electric Company, Schenectady, N. Y.

Local Wire Television Networks

C. N. NEBEL

A new local video distribution system has been developed which provides equalization and amplification of signals transmitted over links between television studios, transmitters, coaxial cables, and microwave networks. The equipment consists of a transmitting terminal, an intermediate repeater with cable equalizers, and a receiving terminal.

A SATISFACTORY local video distribution system is necessary to interconnect television studios, transmitters, and pickup points within a city and to connect them to the coaxial cable and microwave intercity television networks. Wire extension circuits are also necessary to distribute video signals from local microwave circuits which are used to pick up remote program material. A local video distribution system has been developed for the Bell Telephone system utilizing existing telephone facilities as much as practicable.

It is the purpose of this article to describe these video transmission facilities and to show the results obtained with some typical circuit applications.

CHARACTERISTICS OF CABLE PLANT

THE CABLE PLANT in the local exchange areas available for video transmission consists of coaxial cables, existing interoffice trunk and subscriber paper-insulated cables, and shielded polyethylene string and tape insulated cables.

Shielded Video Cable Pairs. A new video cable pair has been developed to meet the demands of the backbone circuits. The high-frequency loss has been kept low by the use of large conductors and polyethylene insulation. The impulse noise and crosstalk have been reduced by shielding the balanced pairs. It is known as *16PSV* (polyethylene shielded video). As shown in Figure 1 each Number 16 American Wire Gauge copper conductor is insulated with a spirally wound polyethylene string and tape. Two spirally wound 3-mil copper tapes with opposite lay then are placed around a pair of the insulated conductors to form the shielded pair. The *16PSV* shielded pairs then are placed in their own lead sheath or in with other paper pairs in large interoffice trunk cables. The average near-end 4-megacycle crosstalk loss between the shielded pairs installed in this manner is about 120 decibels.

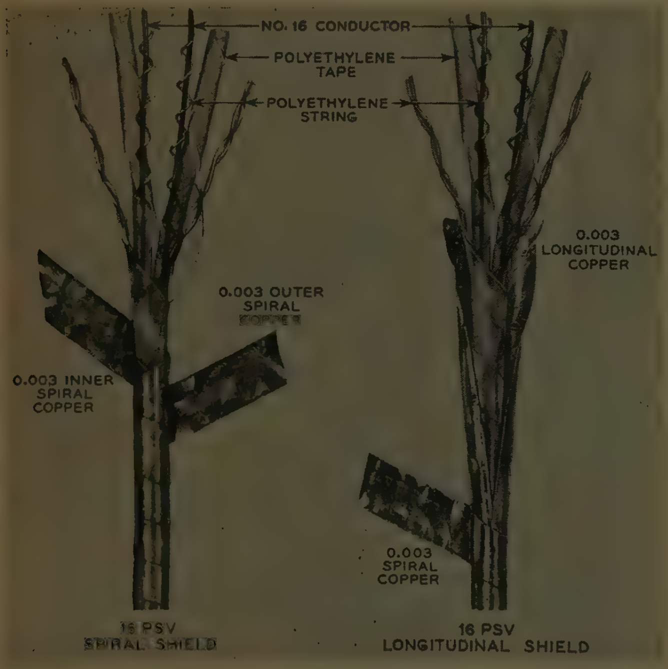
NO. 16 CONDUCTOR
POLYETHYLENE TAPE
POLYETHYLENE STRING
0.003 OUTER SPIRAL COPPER
0.003 INNER SPIRAL COPPER
0.003 LONGITUDINAL COPPER
0.003 SPIRAL COPPER
16 PSV SPIRAL SHIELD
16 PSV LONGITUDINAL SHIELD

Figure 1. Newly developed shielded video cables for use in telephone plant

A modified design now is being produced. The inner shield is a 3-mil longitudinal-seam copper tape with one 3-mil outside spiral tape. The new design has one decibel lower attenuation and about 25 decibels lower crosstalk at 4 megacycles. The impulse noise also is expected to be considerably lower on the new design.

Representative attenuation and impedance characteristics of the shielded video pairs are given in Figure 2. The 4-megacycle loss of the *16PSV* spiral-shield and longitudinal-shield cable is seen to be 18 decibels and 17 decibels per mile respectively. The attenuation-temperature change for a seasonal underground temperature range of 26 degrees Fahrenheit is 0.45 decibel per mile, which is 13 per cent of that for 22-gauge paper pair.

Another cable known as *754C* has been provided for wiring within an office, for quick installations, or when only one or a small number of low-loss circuits are required, usually from an office to a broadcaster. This cable uses solid polyethylene insulation covered with a double braided copper shield which has an outside jacket of grey polyvinyl chloride. The near-end 4-megacycle crosstalk loss between two adjacent *754C* shielded cables is approximately 150 decibels. It is moisture resistant and may be pulled into underground cable ducts.

As previously indicated the near-end 4-megacycle crosstalk is respectively 120 and 145 decibels for the spiral- and longitudinal-shield cables. Experience to date indicates that for the average crosstalk of 120 decibels from the spiral-shield cable, ten tandem repeater links of about

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Essential text of paper **50-234**, "Local Wire Video Television Networks," recommended by the AIEE Committee on Wire Communication Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

C. N. Nebel is with Bell Telephone Laboratories, Inc., Murray Hill, N. J.

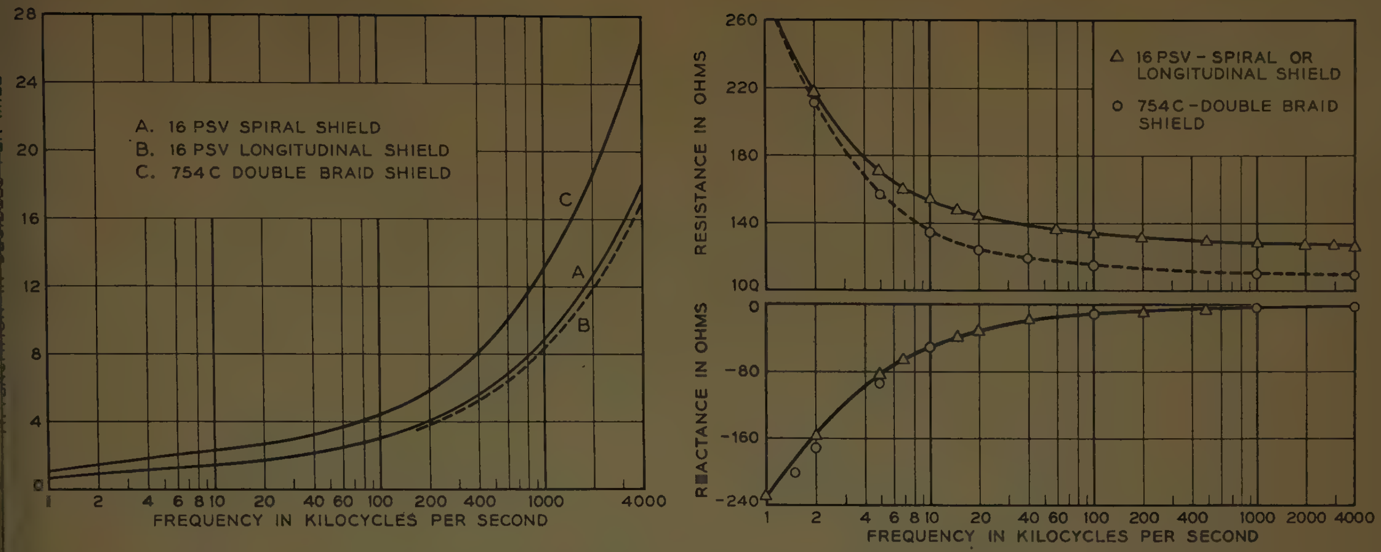


Figure 2. **Attenuation (left) and impedance (right) of newly developed shielded video cables for use in the telephone plant**

5 decibels each at four megacycles should result in subtantially no impairment in picture quality due to crossalk and office impulse noise. This assumes that the gain nd equalization in each repeater is sufficient to make up or the preceding length of cable. However, office spacings nd especially repeater spacings of such great lengths and umbers are not expected to occur frequently. Therefore, should be satisfactory to operate occasional repeater pacings of five to ten decibels longer if repeaters are rovided with sufficient gain, equalization, and shielding or the purpose. An example of a 90-decibel repeater ection is discussed in the special *A2* repeater application lustrated in Figure 12.

A2 VIDEO TRANSMISSION SYSTEM

THE *A2* system at the present time is made up of a transmitting and receiving terminal and the necessary umber of intermediate repeaters for the length of the cable rcuit in use. The line equalization and most of the rcuit gain is furnished by the repeater except in special ases.

Transmitting Terminal. The transmitting terminal consts simply of a repeating coil and associated jacks for ost operational cases. The impedance ratio of the epeating coil is 75:110 ohms and is used to connect the 5-ohm unbalanced impedance of the broadcaster's signal rcuit to the 110-ohm balanced transmission line.

The frequency characteristics of the *197A* and *197B* epeating coils are shown in Figure 3. The *197B* is a later esign with a low-frequency cutoff at ten cycles per second. he use of repeating coils which remove the d-c and other w-frequency signal components is permissible if these gnal components are reconstructed at the receiving end. he low-frequency components are restored by the clamper the receiving terminal and the direct current is restored the receiving tube.

In special cases the repeating coil may be replaced by output amplifier having an unbalanced input impedance 75 ohms and a balanced output impedance of 110 ohms. he maximum voltage gain is 30 decibels, which is adjustable from 20 to 30 decibels in 2-decibel steps. The normal output operating level is two volts, peak to peak, which may be increased three decibels for a maximum of three output amplifiers in a circuit.

When a predistorter is used, its loss must be made up by 20 decibels of gain to give the desired increase in the high-frequency signal components. This gain is furnished by the first repeater when a repeating coil is used in the transmitting terminal. This limits the length of the first repeater link to a maximum of 30 decibels or 1.7 miles of *16PSV*.

A special case exists when the distance to the first repeater office is greater than 1.7 miles. In this case an output amplifier is used to provide the gain for the predistorter and the output network. A maximum loss of 63 decibels or 3.5 miles to the first office repeater is then permissible.

Receiving Terminal. The receiving terminal arrangements are shown in Figure 4. A repeating coil is used to connect the balanced cable pair to the 75-ohm unbalanced circuits. The restorer is used ahead of the clamper, as shown, when the signal has been predistorted at the trans-

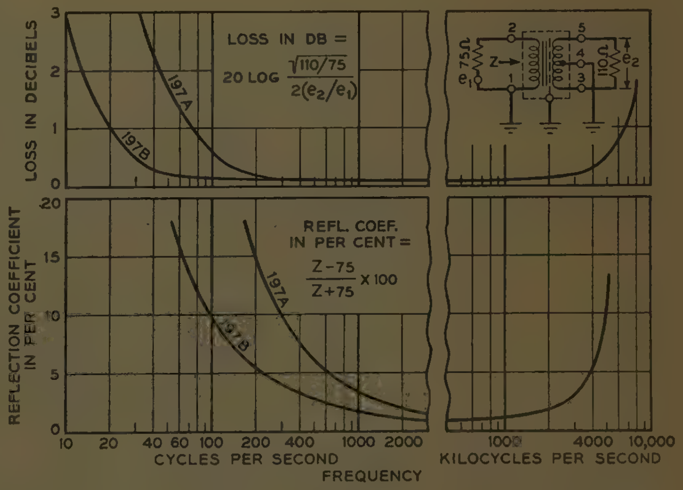


Figure 3. **Transmission characteristics of video repeating coils (line transformers)**

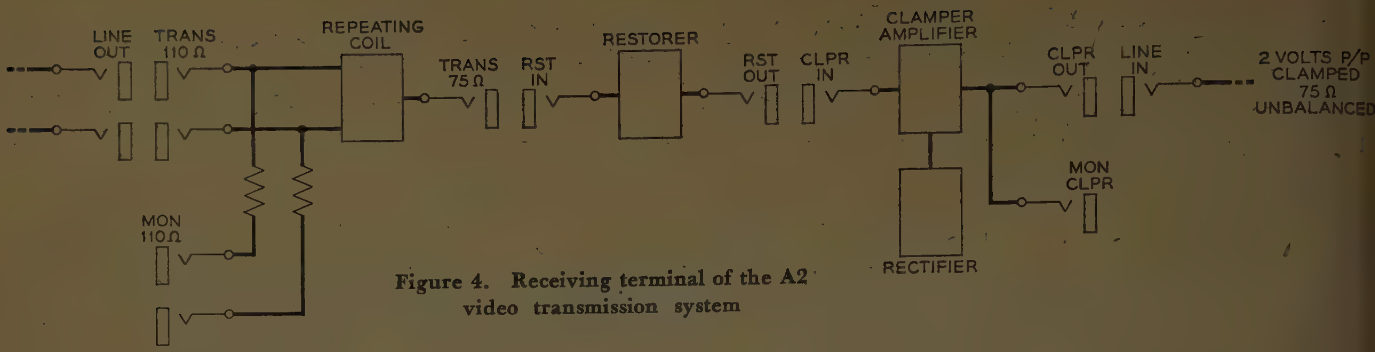


Figure 4. Receiving terminal of the A2 video transmission system

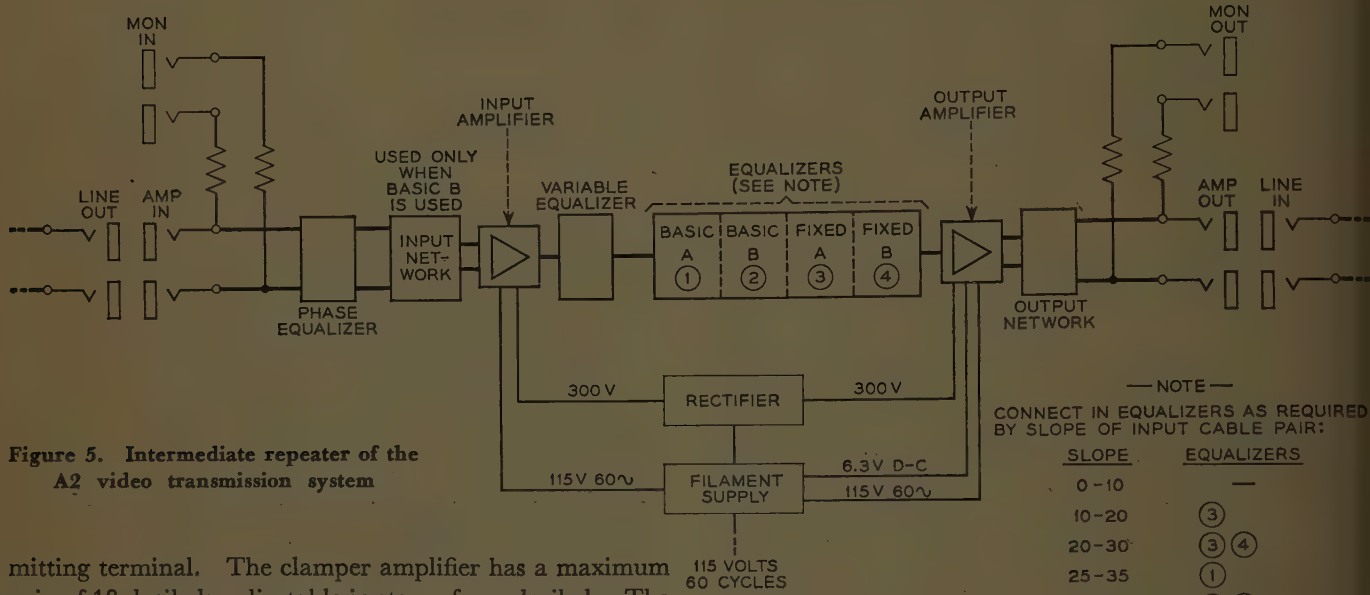


Figure 5. Intermediate repeater of the A2 video transmission system

—NOTE—
CONNECT IN EQUALIZERS AS REQUIRED BY SLOPE OF INPUT CABLE PAIR:

SLOPE	EQUALIZERS
0-10	—
10-20	③
20-30	③④
25-35	①
35-45	①③
45-55	①③④
50-60	①②
60-70	①②③

mitting terminal. The clamper amplifier has a maximum gain of 18 decibels, adjustable in steps of one decibel. The signal delivered to the customer's 75-ohm load impedance is two volts, peak to peak, and clamped.

The *7B* clamper amplifier provides 18 decibels gain and a 31-decibel reduction of 60-cycle interference and a correction for a loss of low-frequency signal components. It is used in the receiving terminal for gain and to restore the low-frequency signal components after transmission through video repeating coils or over circuits whose length is such that increased low-frequency amplitude or phase distortions may result. The theory of design and the operation of this and other clampers has been presented elsewhere.[1]

Intermediate Repeater. The repeater arrangement is shown in Figure 5. When a number of repeaters are used in a telephone central office, they are mounted three on an 11-foot relay rack with the necessary cable terminals and interconnecting jack panels. The repeater consists of three principal elements, the input amplifier, the cable equalizers, and the output amplifier as shown in Figure 5.

The input amplifier consists of an input amplifier network, a balanced input stage of gain followed by a cathode output stage connected directly to the line equalizers. A simplified schematic of the input amplifier is shown in Figure 6. The response characteristic of the network is shown in Figure 7 which is part of the cable equalization. The voltage gain of 13 decibels at the high frequencies is part of the total input amplifier gain. Since it raises the high-frequency signal level at the grids, the noise figure of the input amplifier is improved 13 decibels. Provision is made to remove the input network when it is not needed as equalization or gain for short cable lengths.

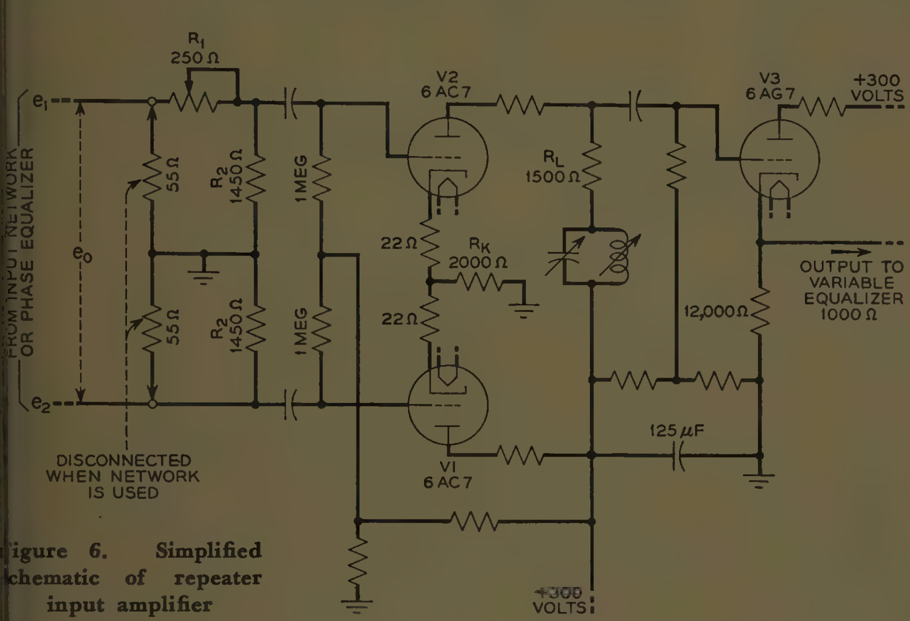
The input longitudinal balance of the amplifier to keep down 60-cycle pickup is provided by the feedback resistance R_K and the balancing adjustment R_1.

The well-known methods of shunt peaking of the interstage plate resistance R_L are used to obtain a 6-megacycle band which has flat amplitude response and very small phase distortion out to four megacycles. The voltage gain of the input amplifier without the input network and terminated in the 1,000-ohm impedance of the cable equalizers is 14 decibels.

The output of the cable equalizer is terminated by the 1,000-ohm input impedance of the output amplifier. This amplifier has three unbalanced gain stages followed by a phase inverter and a balanced output stage. The balanced output stage feeds the balanced cable pair either through the amplifier network or from a 110-ohm termination when it is used as an intermediate repeater. The voltage gain without the output network, but terminated in 110 ohms, is 30 decibels. The normal output operating level is two volts, peak to peak, which may be increased three decibels for a maximum of three output amplifiers in a circuit. A simplified schematic is shown in Figure 8. The amplifier network is the same as the one used in the input amplifier having the response characteristic shown in Figure 7. Shunt peaking of the interstage plate resistance s used to obtain a 6-megacycle band which has flat ampliude response and very small phase distortion out to four negacycles. Plate load decoupling is used in individual tages to obtain good transient response at the very low requencies.

Over-all Repeater. The tandem operation of many epeaters requires that systematic irregularities be kept to ery small limits. Therefore, the response below four negacycles is capable of adjustment to ±0.05 decibel in nanufacture or subsequent maintenance work if sufficient are is exercised. The greatest part of this irregularity ccurs above two megacycles, and it is practically zero in he more critical region of the band below 500 kc.

The common operating procedure is to receive a 2-volt eak to peak signal from the customer to operate each epeater output at two volts peak to peak and to return o the customer at the receiving end of the circuit two volts eak to peak into a 75-ohm load. The low-frequency oss of the cable pair may be anything from near zero for ery short circuits to five decibels for a 3.5-mile circuit of *6PSV*. Since the input amplifier operates directly from he line, its overload at low frequencies is important. The verload in the input amplifier and the output amplifier f a repeater has been kept low so that compression at perating signal levels is negligible with ten repeaters used n tandem.



igure 6. Simplified chematic of repeater input amplifier

Equalization of Cable Characteristic. The equalization of the able characteristic is accomplished by using multiples of hree constant resistance equalizer units located between he input and output amplifiers. These equalizers are eferred to as basic, fixed, and variable.

The basic is always associated with an amplifier network. Referring to Figure 7, it will be seen that the sum of the haracteristics of the amplifier network and the basic qualizer gives curve *C* which is the inverse characteristic f *16PSV* cable loss. It has been plotted as response nstead of loss so it may be easily recognized as proportional o the *16PSV* cable characteristic shown on Figure 2. This combination of units will equalize 25 decibels of 4-megacycle *16PSV* cable loss.

The fixed unit will equalize ten decibels of 4-megacycle *16PSV* loss. The 10-decibel step of the variable unit has the same characteristic as the fixed unit. The variable unit is adjustable in 12 proportional 1-decibel steps. It consists of two sections in tandem. The sum of these two sections gives the desired loss characteristic *C* as shown in Figure 9. Each section is independently adjustable to give the 12 proportional 1-decibel steps.

There is a very small amount of residual high-frequency phase deviation in each repeater link that is removed by the phase equalizer indicated in the repeater block diagram.

Space for five cable equalizer units is provided on a panel located between the input amplifier and the output amplifier. A variable unit and the correct number of basic and fixed units thus are connected in tandem to equalize a given length of cable preceding a repeater. Since there can be a maximum of two amplifier networks per repeater, a maximum of two basic equalizers may be utilized per repeater. The first of these two networks to be utilized in equalizing a line is the output network at the preceding repeater. If the 4-megacycle line loss is 50 decibels or greater, the repeater input network then is added. Fixed and variable equalizers then are added as needed for longer lengths of cable. The gain of the amplifiers with the equalization that is provided allows for a maximum repeater spacing of about 3.5 miles of spirally shielded *16PSV* or 63 decibels' line loss at four megacycles. The general result of the equalizer loss is to attenuate low frequencies more than high

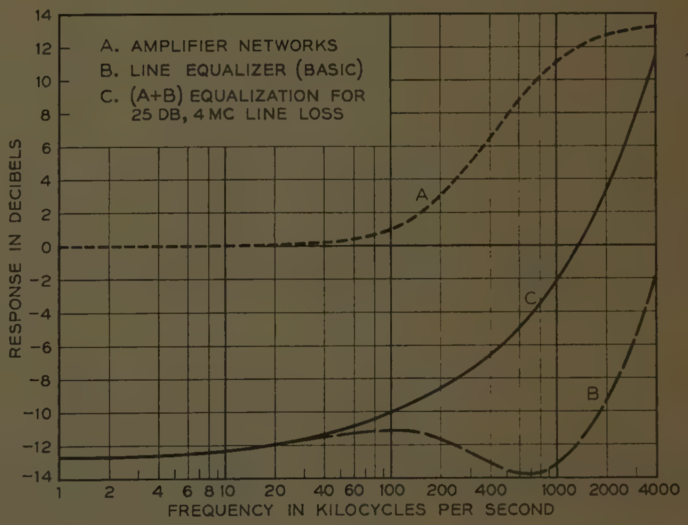
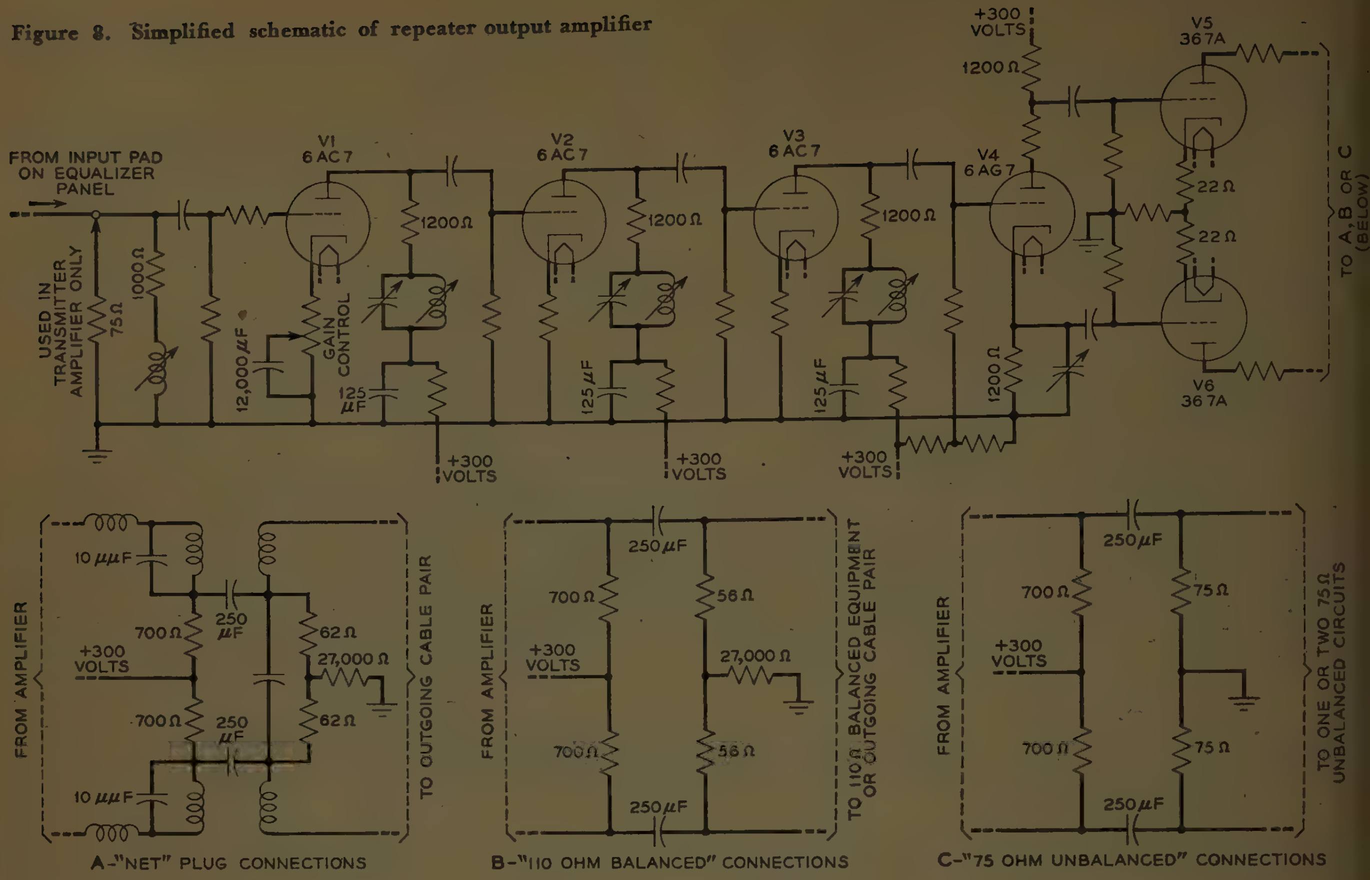


Figure 7. Characteristics of cable equalizers. (A) Amplifier networks, (B) basic 16PSV cable equalizer, (C) sum of amplifier network and basic equalizer for 4-megacycle cable loss of 25 decibels

Figure 8. Simplified schematic of repeater output amplifier


FROM INPUT PAD ON EQUALIZER PANEL
USED IN TRANSMITTER AMPLIFIER ONLY
75Ω
1000Ω
12,000 μF
GAIN CONTROL
125 μF
V1 6AC7
1200Ω
+300 VOLTS
V2 6AC7
V3 6AC7
V4 6AG7
V5 367A
V6 367A
22Ω
TO A, B OR C (BELOW)
FROM AMPLIFIER
10 μμF
700Ω
250 μF
62Ω
27,000 Ω
TO OUTGOING CABLE PAIR
A-"NET" PLUG CONNECTIONS
56Ω
TO 110Ω BALANCED EQUIPMENT OR OUTGOING CABLE PAIR
B-"110 OHM BALANCED" CONNECTIONS
75Ω
TO ONE OR TWO 75Ω UNBALANCED CIRCUITS
C-"75 OHM UNBALANCED" CONNECTIONS

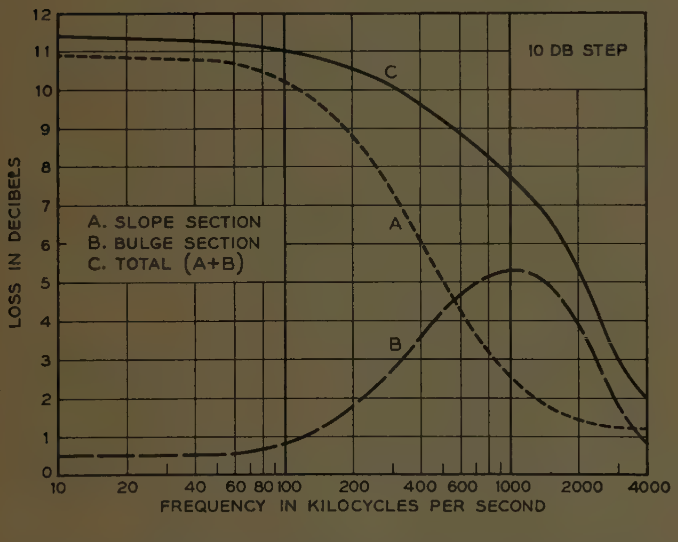


Figure 9. Characteristics of variable and fixed cable equalizer units. (A) Slope section, (B) bulge section, (C) sum of both sections, each of which are adjustable in the variable equalizer

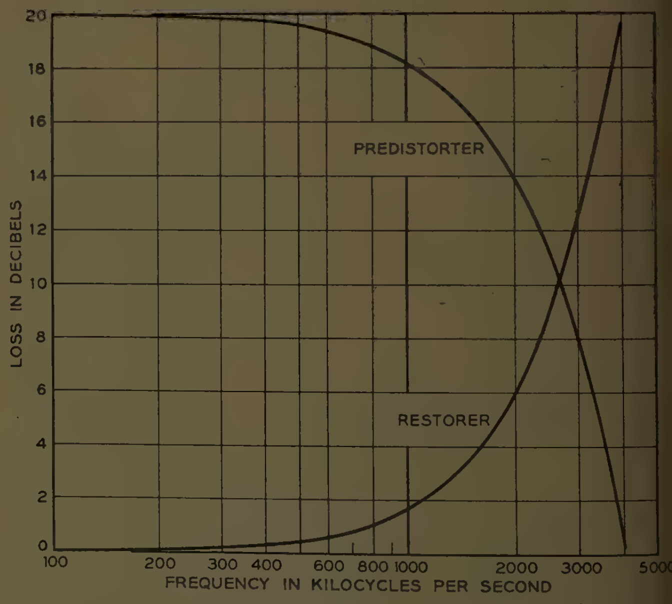


Figure 10. Loss characteristics of predistorter and restore networks used for noise protection

frequencies and in the proper amount so that over-all response of the line and equalizer is uniform to a transmitted signal. The impulse noise, originating at the receiving end of the cable, with the cable and amplifier input noise, become attenuated with the low-frequency signal components. Therefore, there is a noise reduction in the low-frequency region. There is, also, a reduction in the interfering effect of the noise due to its concentration in the high-frequency band. The use of the output network at the preceding repeater as part of line equalizatio increases the high-frequency sending level 13 decibel without increasing the overloading in the output amplifier This results in an added noise improvement of 13 decibels

Noise Reduction by Signal Predistortion. The use of th predistorter at the transmitting terminal results in a added noise reduction for long repeater links. The pre istorter characteristic is given in Figure 10. The 20-ecibel low-frequency loss is made up at the first repeater. Vhen 20 decibels of gain are used at the first repeater to ıake up for the 20-decibel low-frequency loss of the pre-istorter, the high-frequency signal components thereby re increased on the outgoing line. This predistorted gnal shape is retained throughout the remainder of the rcuit.

It is eventually restored to its original shape at the re-eiving terminal by the use of a complementary equalizer haracteristic, shown in Figure 10. Since this restorer has ie high loss characteristic shown at the high frequencies , also, attenuates high-frequency noise. This results in n average improvement in signal-to-impulse noise of 16 ecibels and an improvement of almost 20 decibels in the gnal-to-random noise from the cable and input amplifier. owever, this reduction of noise is not obtained without me penalty. The load capacity of the repeater output age must be increased some four decibels because of the dverse peak factor of the pre-equalized signal. The net ain in signal-to-noise ratio is, therefore, four decibels less an the values given.

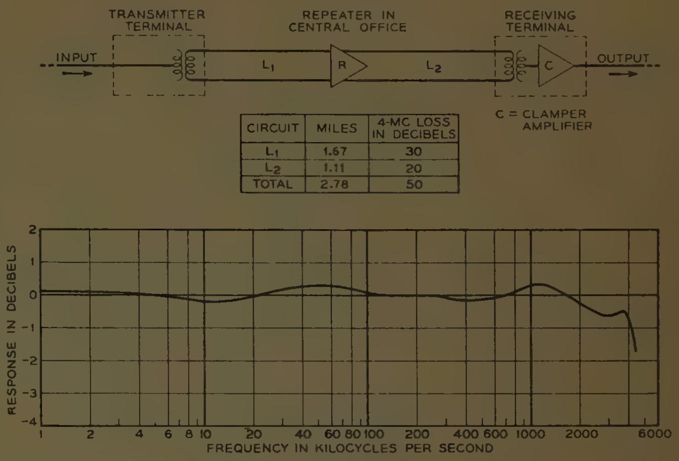
CIRCUIT APPLICATION

HE APPLICATION of this video transmission system can best be shown by the use of two typical *16PSV* circuit ses.

The simplest circuit case is the one where a central fice repeater is located between the transmitting and ceiving terminals as shown in Figure 11. In this case e circuits are short and noise protection is not needed. he maximum cable slope characteristic that can be ualized in this case is $L_1+L_2=69$ decibels, with the striction that $L_2 \leq 27$ decibels. This restriction is neces-ry to prevent the output amplifier from overloading on e high peaked signals resulting from the pre-equalization r the final link. In the case shown in Figure 11 the loss L_1 and L_2 are 32 decibels and 20 decibels respectively. he transmission response of the circuit is as shown in the ure.

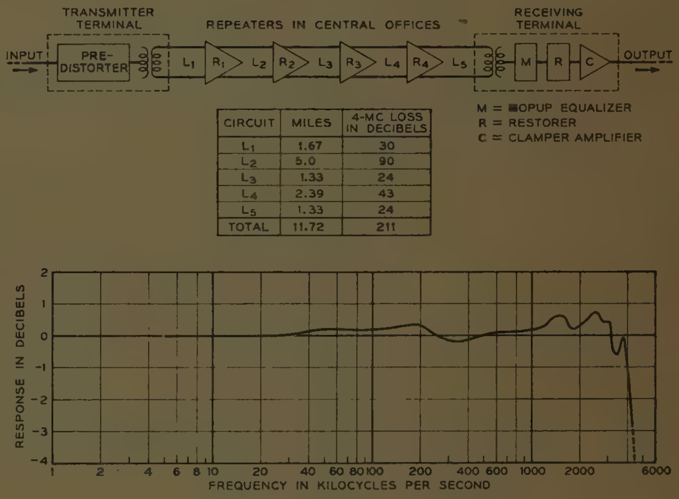
A more complex circuit application is illustrated in gure 12. The total length of the five video lines is 11.72 iles having a total 4-megacycle loss of 211 decibels. lso, it will be observed that line L_2 is five miles in length ith a 4-megacycle loss of 90 decibels and the normal erating procedures must be modified to accommodate is special case.

There is not enough gain or equalization in repeater , to operate a 90-decibel line. However, it is accom-ished in this case by altering the operating procedure in ree ways. First, it is permissible to operate the output repeater R_1 at a level which is 3.5 decibels higher than ormal. Second, since line L_3 is short the output network repeater R_2 can be used in the equalization of line L_2. his equalization occurs in the form of 13 decibels of high-equency gain instead of low-frequency loss. Third, ice line L_3 is short there is no noise protection problem repeater R_3, so the output level of repeater R_2 can be erated the necessary ten decibels lower than normal. he signal arrives at repeater R_3 ten decibels lower than normal and is raised to normal by use of excess gain in repeater R_3. In this manner the 27 decibels of gain has been obtained to increase the normal repeater spacing of 63 decibels to 90 decibels. This cannot always be done, however, and it is seldom desirable to deviate from a standard operating procedure, but in this particular case it made the operation of an off-premise extra repeater unnecessary.



CIRCUIT	MILES	4-MC LOSS IN DECIBELS
L_1	1.67	30
L_2	1.11	20
TOTAL	2.78	50

Figure 11. **Simple circuit application of the A2 video transmission system**



CIRCUIT	MILES	4-MC LOSS IN DECIBELS
L_1	1.67	30
L_2	5.0	90
L_3	1.33	24
L_4	2.39	43
L_5	1.33	24
TOTAL	11.72	211

Figure 12. **Complex circuit application of the A2 video transmission system**

The remainder of the circuit follows normal operating procedure. A final mop-up equalizer is located at the receiving terminal to reduce the amplitude of the residual transmission distortion characteristic.

The video transmission system is ordinarily applied according to a standard operating procedure. However, it has been shown by a complex circuit application that it can be flexibly applied to care for difficult nonstandard operating conditions.

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Interrupting Ability of Horn-Gap Switches

F. E. ANDREWS
MEMBER AIEE

L. R. JANES
FELLOW AIEE

M. A. ANDERSSON
ASSOCIATE AIEE

A HORN-GAP switch has limitations in its ability to successfully open a circuit because of the restricted space available for expansion of the arc. It is not the length of the arc but its spread, and where it goes, that is important in switch operation. The clearance available for the spread of the arc must be such that the arc cannot form a short circuit between phases or to ground.

An investigation including about 400 test openings of current has been made by the Public Service Company of Northern Illinois to determine magnitudes of current that can be successfully interrupted and to determine basic switch design factors for successful operation.

"Reach" has been defined as a measure of the spread to provide a criterion for comparison with switch clearances. Arc reach is defined as the distance from a point midway between the arc extremities to the most remote point of the arc at the time of its maximum length. Reach is most critical when its direction happens to be towards the nearest live part of another phase or ground (usually perpendicular and crosswise to switch alignment).

The tests included interruption of (1) currents up to 312 amperes in one side of a 33-kv transmission loop, (2) transformer exciting currents up to 35 amperes and at voltages up to 49 kv, and (3) 132-kv line charging current up to 20 amperes, with and without gas blast. By measuring the reach on the two motion picture views of each arc which were taken with cameras at right angles and by assuming that arc length is proportional to voltage, expressions were developed relating the expected reach in feet per kilovolt to the current interrupted.

Within the range of these tests it has been concluded that the upper limit of probable reach associated with opening the current on one side of a transmission loop or the exciting current of a transformer is

Range in Amperes	Probable Reach
0 to 100	$0.0165 \times \text{kv} \times I$
100 to 320	$1.65 \times \text{kv}$

where reach is in feet, kv is in rms kilovolts across the separated horns after opening, and I is the rms current interrupted in amperes. These limits are not applicable to interruption of line charging current or static capacito on account of the "trapped charge" after opening.

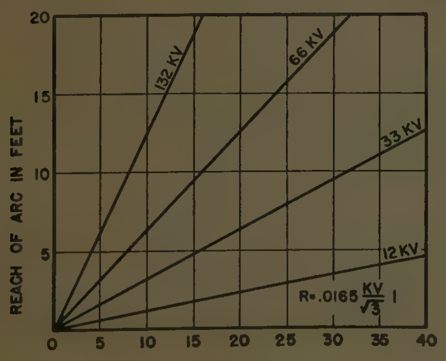

Figure 1. Arc reach for small currents at various line voltages

Figure 1 shows the reach of arc in feet plotted agains resistive or inductive current interrupted. It is par ticularly applicable for determining reach when openin transformer exciting current. Similar graphs can b plotted for opening loop current, each curve representin either voltage across the open switch gap or loop impedanc In the latter case the range of voltages across the switc gap is much lower (usually from 5 to 40 per cent of nomina line to neutral voltage). In applying the formulae give previously for probable reach, the voltage must be dete mined for a given current. In the case of dropping loa such as opening transformer exciting current, the voltag is that between line and neutral of the supply. In openin loop current, it can usually be obtained with sufficien accuracy by multiplying the current to be interrupted b the impedance of the transmission loop which contains th line to be opened by the horn-gap switch. When the prob able reach has been determined, it must be compared wit the clearance of the switch. For successful operation som margin between reach and clearance should be allowed.

The 132-kv line tests covered interruption of chargin current up to 20 amperes without gas blast and wit nitrogen or air directed into the arc at 115 pounds pe square inch. With switches having 16 feet of horizonta phase spacing, it was concluded that 132-kv charging cu rent can be safely interrupted without gas blast up to seve amperes. The successful opening of currents as hig as 20 amperes with arc lengths up to 123 feet and reache up to 25 feet was due to the favorable wind direction.

MAJOR CONCLUSIONS

1. A horn-gap switch will successfully interrupt a cu rent if its dimensions are adequate to permit the arc to gro to the critical length at which it goes out, unless the win is blowing in line with the arcing horns.
2. For resistive and inductive loads reach for currents be low 100 amperes depends on both voltage and curren Maximum reach for practical use in this range is 0.016 foot per ampere per kilovolt across the open switch gap.
3. For resistive and inductive loads reach for curren from 100 to 320 amperes is proportional to voltage but inde pendent of current magnitude. Maximum practical reac in this range is 1.65 feet per kilovolt across the switch gap.
4. On 132-kv switches having 16 feet of horizontal sep ration between phases, about seven amperes (approx mately 17 miles of line) can be opened safely.

Digest of paper 50-161, "Interrupting Ability of Horn-Gap Switches," recommend by the AIEE Committee on Transmission and Distribution and approved by the AI Technical Program Committee for presentation at the Summer and Pacific Gene Meeting, Pasadena, Calif., June 12–16, 1950. Scheduled for publication in AI *Transactions*, volume 69, 1950.

F. E. Andrews, L. R. Janes, and **M. A. Andersson** are all with the Public Serv Company, Chicago, Ill.

Underground Conduit for Electric Power Systems

E. G. WATKINS

ELECTRIC CONDUITS of one type or another have been in use since the beginning of the electric power ndustry. Construction practices and materials are fairly vell standardized within companies. There is no accepted ingle standard for the industry, and it is probable that io single standard could be designed that would be satisactory. However, since the fundamentals and basic lesign considerations are the same throughout the industry, ny discussion concerning these principles is pertinent to ll conduit design. In recent years, probably the only new levelopment involving conduit construction is the installaion of high-voltage transmission cable in steel pipe with as or oil under high pressure. The cost and lack of lexibility usually restrict this new system to high-capacity ransmission uses.

A standard underground conduit system can usually e adopted by a utility company which has, or is in the rocess of placing, its electric transmission and distribuion facilities underground. In order to standardize, onduit material and design installation must be made to onform with general conditions. Special methods should e reserved for locations where, because of either cost or hysical conditions, standard procedures would not be atisfactory.

Fundamentally, a conduit system is good or bad deending upon its suitability for the installation, operation, rotection, and maintenance of the cables which it is to ontain. Fundamentals and basic considerations for onduit design and the construction of conduit systems re not essentially different now than they have been in the ast, but progress in the art of electric transmission freuently adds or detracts emphasis to certain features of onduit design. For example, the growing tendency to nstall cables of greater capacity and to carry greater loads n existing systems requires that serious consideration be iven to the thermal characteristics of a conduit system.

The complexity of the design problems pertaining to an nderground conduit system will depend on whether it intended as a new system in which there will be a greater lexibility of choice with respect to materials and methods r whether it is intended to extend or modify an existing nderground conduit system. Co-ordination and comromise are necessary to attain the most satisfactory lectrical, mechanical, and economical arrangement.

A basic requirement for a conduit design is to know the aximum permissible length of the conduit section beween manholes or splicing chambers. This is a controersial subject dependent upon permissible cable-pulling resses and friction factors of the conduit; there are nearly s many rules for determining this length as there are lectrical companies. Having determined the maximum ngth of straight conduit sections between manholes, the ext controversial item is the effect of bends of varying degree and radii. In the design of a conduit system, bends of varying degree may be expressed as equivalent lengths of straight conduit. This equivalent length varies, depending upon the distance of the bend from the cable feeding end of the conduit section. Based on a series of tests, a chart has been prepared from which these equivalent lengths can be determined readily and rapidly. A significant fact, developed during the studies, is that within reasonable limits the radius of the bend does not affect its equivalent length. The fact that a bend of larger radius has a greater over-all length is the compensating feature.

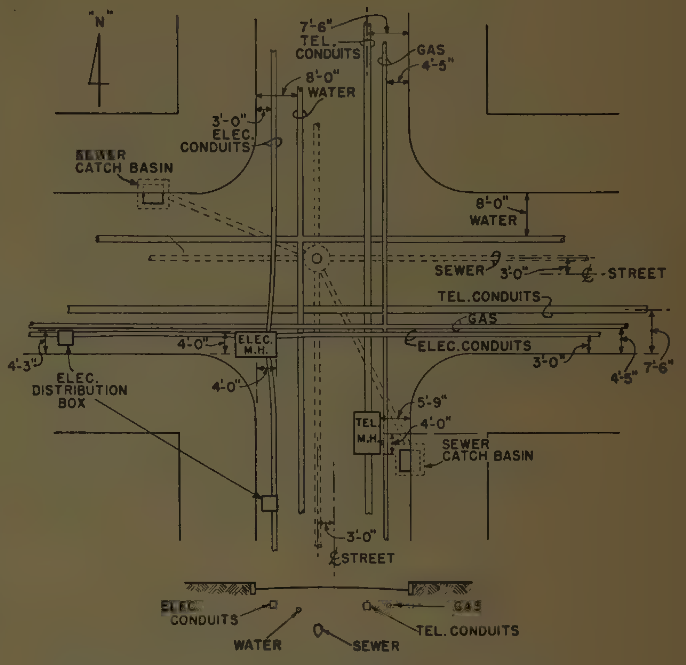

Figure 1. Typical utility lanes in the street

Street layouts are of prime importance in the design of a conduit system. It is important that a conduit system be installed in a location convenient for distribution purposes and still so located that the likelihood of interference from foreign constructions is remote. This frequently involves obtaining satisfactory agreement with local municipal authorities and other utilities in order to preserve an orderly and satisfactory arrangement of all structures in a street (see Figure 1).

Both the designer and the builder should constantly keep in mind that not only must a conduit system be structurally satisfactory but it must meet requirements for good cable installation, operation, and maintenance.

Digest of paper **50-257,** "Underground Conduit for Electric Power Systems—Fundamentals and Basic Design Considerations," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

E. G. Watkins is with the Consolidated Edison Company o. New York, Inc., New York, N. Y.

Voltage-Regulated D-C Systems

D. G. SCORGIE
ASSOCIATE AIEE

THE FACTORS affecting transient operation of a voltage-regulated d-c system have been studied empirically in the past, but a need has been felt to have a greater analytical understanding of the problem in aircraft system work. A step in this direction is to draw upon linear servomechanism and closed-loop control theory. An analysis of the carbon-pile regulator has been published with this purpose in mind.[1]

This article incorporates the previous analysis into a study of the whole system. A transfer function for the d-c generator has been derived taking as the input variable changes, $R(t)$, of the shunt field circuit resistance from some initial operating point, and taking as the output the corresponding variations, $E_0(t)$, of the terminal voltage. For input values which are small relative to the total field circuit resistance, the no-load transfer function of a shunt-wound d-c generator is given by

$$T_g(s) = +K_g\left(\frac{\alpha_g}{s+\alpha_g}\right) \qquad (1)$$

where

$$K_g = \frac{K_s}{R_1 - K_s} \text{ and } \alpha_g = \frac{R_1 - K_s}{L_f}$$

and K_s is the slope of the no-load saturation curve at the operating point; R_1 is the shunt field circuit resistance at the initial operating point; and L_f is the incremental self inductance of the shunt field circuit.

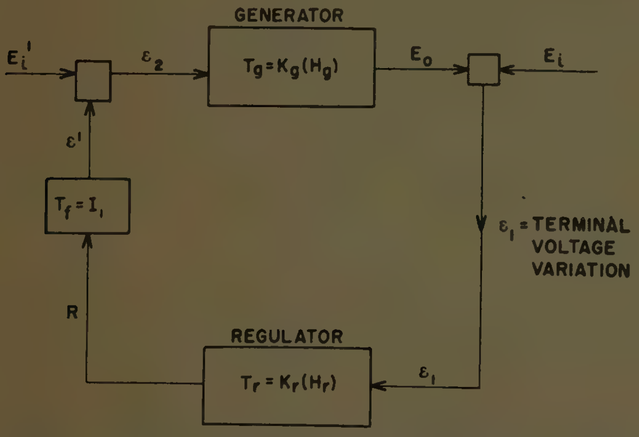

Figure 1. Block diagram of system consisting of shunt generator and carbon-pile voltage regulator

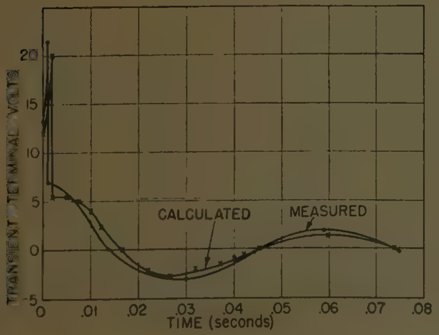

Figure 2. Measured and calculated system response to removal of full load

The carbon-pile regulator transfer function is the re sistance output divided by voltage input and can b approximated by

$$T_r = K_r\left(\frac{\alpha_r}{s+\alpha_r}\right) \qquad (2$$

where

$$K_r = \frac{UP}{KR_c}$$

$$\alpha_r = \frac{R_cK}{U^2+KL}$$

where U is a magnetic coupling coefficient; P is the rat of change of carbon-pile resistance per change of carbon pile stack length; R_c and L are the resistance and incre mental self-inductance of the operating coil circuit; an K is the difference in slopes of magnets and carbon-pil force deflection curves.

The system comprised of a single shunt generator wit carbon-pile voltage regulator can be represented schematic ally by a block diagram shown in Figure 1. Disturbance such as load changes can be translated into equivalen voltage inputs E_i and E_i', and the transform of the resultin terminal voltage transient is given by

$$\epsilon_1(s) = E_i'(s)\left(\frac{T_g}{1-\dfrac{E_0}{\epsilon_1}(s)}\right) + E_i(s)\left(\frac{1}{1-\dfrac{E_0}{\epsilon_1}(s)}\right) \qquad (3$$

Figure 2 shows a measured terminal voltage transien resulting from the removal of full load from the system an shows also the response as calculated from equation 3.

It can be shown that in the case of load current change the only equivalent voltage inputs which affect the genera tor terminal voltage are those due to the change of th voltage drop in the armature resistance drop and the self inductance of the armature circuit (including commutatin and compensating windings) during the load removal. I also can be shown that excellent qualitative predictions o system stability and performance can be obtained b examining the loop transfer function, $(E_0/\epsilon_1)(s)$, in th vicinity of the $1+j0$ point.

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Digest of paper **50-208**, "Transient Analysis of a Voltage-Regulated Aircraft D- System," recommended by the AIEE Committee on Air Transportation and approve by the AIEE Technical Program Committee for presentation at the AIEE Middl Eastern District Meeting, Baltimore, Md., October 3–5, 1950. Scheduled for publica tion in AIEE *Transactions*, volume 69, 1950.

D. G. Scorgie is with the Naval Research Laboratory, Washington, D. C.

Ice Testing of Outdoor Disconnecting Switches to Simulate Field Conditions

J. B. OWENS
ASSOCIATE AIEE

The problems involved in testing outdoor switches to determine their effectiveness as ice-breaking mechanisms are numerous. This article describes an ice test and the design features of a switch which can be operated under severe icing conditions.

THE ICE STORM is one of the major difficulties encountered in the operation of electric power systems. Under certain atmospheric conditions a deposit hard clear ice can build up in a few hours to a thickness hich causes overhead lines to fail, and which renders the peration of outdoor switching equipment very difficult. o overcome operating difficulties under these conditions any ingenious outdoor switches which employ some uxiliary blade motion to break ice have been developed. his blade motion has been accomplished by a great variety mechanisms, and doubtless many other different varieties ill follow.

The testing of these outdoor switches to determine the fectiveness of their ice-reaking mechanisms has ng been a problem to both itch manufacturers and ower system engineers. In ost locations, severe ice orms occur infrequently so at testing under natural nditions becomes impracti-l. Thus the problem arises producing artificially the thickness and density of ice coat-g which occurs in nature. If any outdoor switch were ozen in a giant ice cube large enough to contain the entire itch, obviously it would be inoperable. Therefore, testing ust be done with an ice thickness comparable to that tually encountered in service. Also, the strength and pacity of an ice coating varies considerably with variations the air temperature, water temperature, and rate of plication. These factors must be controlled carefully obtain proper results. It is the purpose of this article describe an ice test which produces conditions com-rable to those obtained in the field, and to describe the sign features of a switch which can be operated easily der severe icing conditions.

FORMATION OF ICE

THE WEATHER conditions which most often produce severe ice storms are those which prevail when a rm air mass has overrun a cold air mass so that rain is ling through air which is slightly below freezing. Such rm fronts usually extend over a considerable area producing wide precipitation belts, and these fronts are slow moving compared to cold fronts so that the rain may persist for a number of hours.

Under the conditions described, the falling water is cooled by evaporation and by its travel through the cool air mass so that it freezes almost instantly upon contact with objects on the earth. When the temperature of the air near the ground is only a few degrees below freezing, the ice which is formed is hard and clear and free from the inclusion of air bubbles. This is the kind of coating which creates the greatest difficulty in switch operation.

In general, ice which is formed at a very low temperature (below 15 degrees Fahrenheit) and ice which is formed from moisture condensing from the air onto cold surfaces has a very porous and weak structure.[2] Such ice is called rime ice and is characterized by a white, rather than a clear, appearance. This appearance is a result of the many small air spaces included in the structure. A good example of rime ice is the formation on the cooling coils of a home refrigerator.

It has been found that if switches are cooled to temperatures below 15 degrees Fahrenheit and are sprayed with a fine mist, a coating of rime ice is deposited. This coating is very easily broken even when the thickness is great, and such a test is not a real measure of the ice-breaking ability of the mechanism.

A test which has been found to give consistently a clear hard ice deposit is as follows:

1. Assemble all poles and mechanism of the switch on a structure to permit normal operation. The operating pipes may be shortened in order to suit any space requirements.

2. Clean all traces of oil or grease from all outside switch surfaces. Even thin films of oil or grease prevent ice from adhering to the switch and greatly change test results.

3. With the switch blade in the desired position, lower the air temperature to 35 degrees Fahrenheit and then spray the switch with water which has been cooled to approximately 35 degrees Fahrenheit. This spray should be arranged to simulate a general rain and not a fog or mist. The water should fall from above and at an angle not exceeding 45 degrees from vertical. The location of the water spray should be such that the pole units and

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l text of paper 50-239, "Ice Testing of Outdoor Disconnecting Switches to Simulate d Conditions," recommended by the AIEE Committee on Switchgear and approved he AIEE Technical Program Committee for presentation at the AIEE Fall General ting, Oklahoma City, Okla., October 23–27, 1950. Scheduled for publication in E *Transactions*, volume 69, 1950.

. **Owens** is with the Westinghouse Electric Corporation, East Pittsburgh, Pa.

author wishes to acknowledge the contribution to these tests made by W. R. Smith, rge Lambert, and other engineers of the Pennsylvania Power and Light Company.

the entire operating mechanism are covered with a uniform rainfall.

4. After the rain is started, the air temperature should be lowered at the rate of approximately 3 degrees Fahrenheit per hour to a final temperature of 25 degrees Fahrenheit. This causes the switch to be sprayed for an hour before freezing temperature is reached, and the switch is thoroughly wet when freezing begins. The amount of water supplied should be such that ice forms at the rate of about 1/4-inch per hour.

5. Continue the spraying while holding the air temperature between 25 and 30 degrees Fahrenheit until a deposit of ice one inch thick has formed.

6. After the ice has been deposited, the switch may be operated and the operating effort noted.

TYPICAL TEST ARRANGEMENT

A LABORATORY setup to make the test described above is shown in Figure 1. The switches which were tested were two 15-kv 400-ampere 3-pole manually gang-operated air switches with offset torsional mechanisms. Figure 1 also shows the pipes which comprised the spraying system to create the rain on the switches. These pipes were located at the level of the switch bases and were supplied with water cooled to 35 degrees Fahrenheit by being circulated through a coil embedded in dry ice. The pipes were 1/2-inch thin-wall brass tubing and were drilled with 0.028-inch diameter holes on 9-inch centers to release the spray.

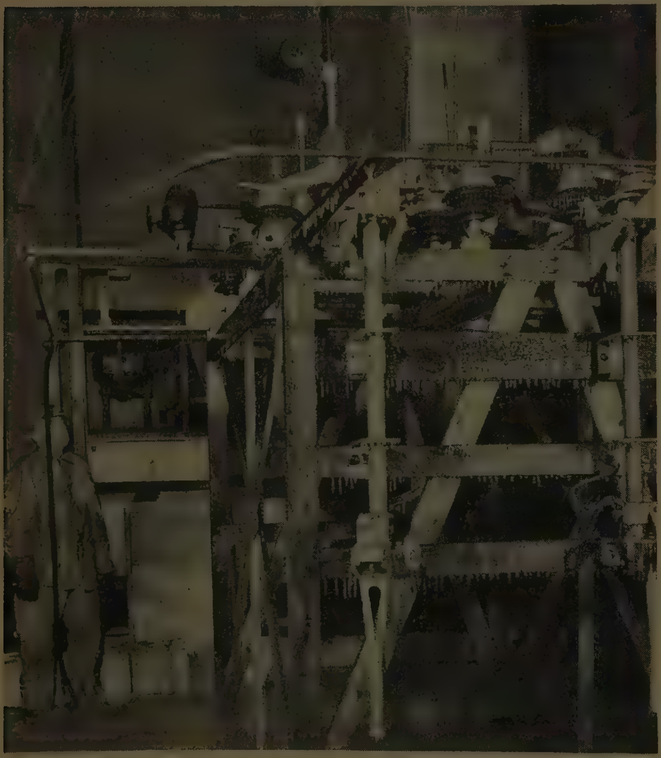

Figure 1. Setup for the ice test of two 15-kv 400-ampere air switches

The water pressure was adjusted so that the stream would rise about six feet into the air before falling ont the switches. With this particular arrangement 1. gallons of precooled water were sprayed per hour pe square foot of area sprayed to cause the ice to form at th desired rate. An air blower in the cold chamber serve to agitate the rainfall to assist in uniform distribution ove the switch.

Figure 2 shows the arrangement used to precool th water for the rain. Tap water was used, and it was coole by being passed through 120 feet of 1/2-inch coppe tubing wound into a coil surrounded with dry ice. Th coil was placed in a micarta tube approximately 16 inche in diameter and 30 inches long. Dry ice chips were packe in the center of the coil. The output water temperatur was controlled by varying the amount of dry ice which wa used and the density of the packing of the chips in th center of the coil.

Figure 3 shows the clarity of the coating on the tes switches after ice has been deposited. After the switche were operated, they were placed in an intermediat position between open and closed, as shown in Figure 4 in which it can be seen how the blade twisting motion an the flexing of the jaws have cleared the ice from the contacts.

Figure 2. Dry-ic chamber for pre cooling water wit which to spra switches

MEASUREMENT OF ICE THICKNESS

ONE OF the chief problems in making tests of this kin is that of knowing when the right quantity of ice ha been deposited. Many utility company specificatio have been studied, and "one inch of radial ice" is mo commonly specified for testing of this kind. A fina thickness of one inch is suggested as a standard for testin since this amount is rarely exceeded in service in the continental United States. However, ice does not form wit uniform thickness over all switch surfaces, and the furthe problem arises of determining the correct place to measu the ice.

On a power transmission or distribution system whic has been blanketed with an ice storm, the ice of greate interest, and that which has the most nearly unifor thickness, is that formed on horizontal overhead conductors. Around these circular conductors ice is forme th approximately uniform thick- ss. A measure of the radial ckness of the coating on a hori- ntal conduct is a fair measure of e severity of the storm which has curred.

On outdoor air switches ice forms ch more rapidly on some surfaces n others. Therefore, a measure- nt of the ice at any one place the switch will probably not e a fair measure of the severity of coating. .One method which s given good results is to mount a ce of copper cable so that it is rizontal and receives the same nfall as the switch. A measure- nt of the ice thickness at the top e of this conductor can be taken an index of the thickness of the coating which has formed on the tches.

Many of the outdoor air switches w on the market have a single de of circular section. A measure the ice on the top side of the blade uch a switch in the closed position npares closely with ice on a cir- ar conductor, and can be used as neasure of the severity of the ice rm

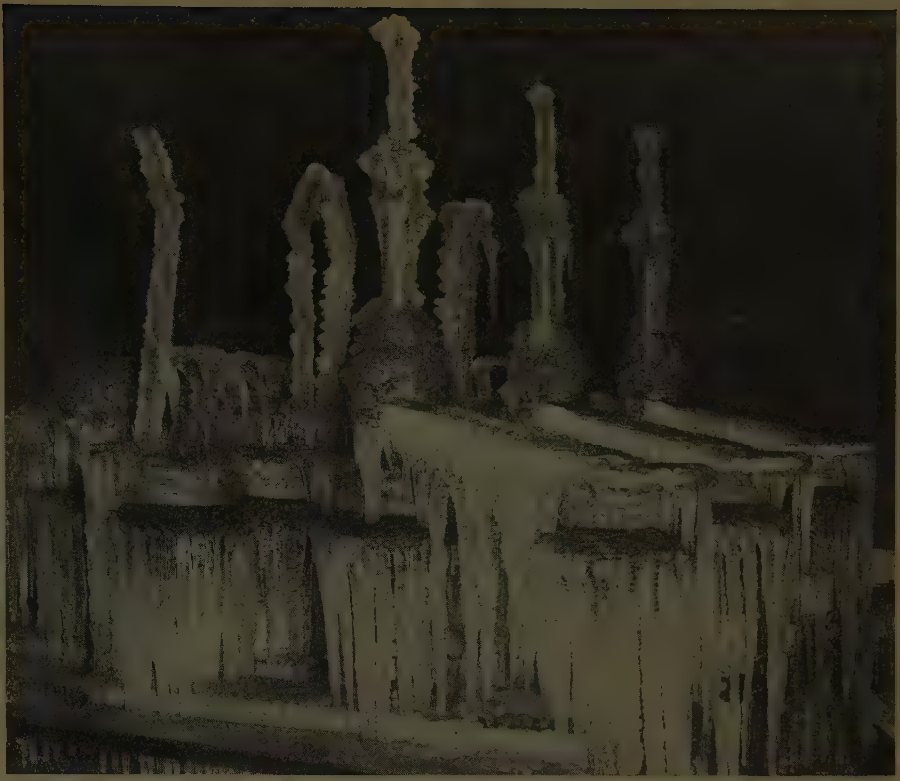

Figure 3. Close-up view of final ice coating showing the exceptionally heavy clear ice coating

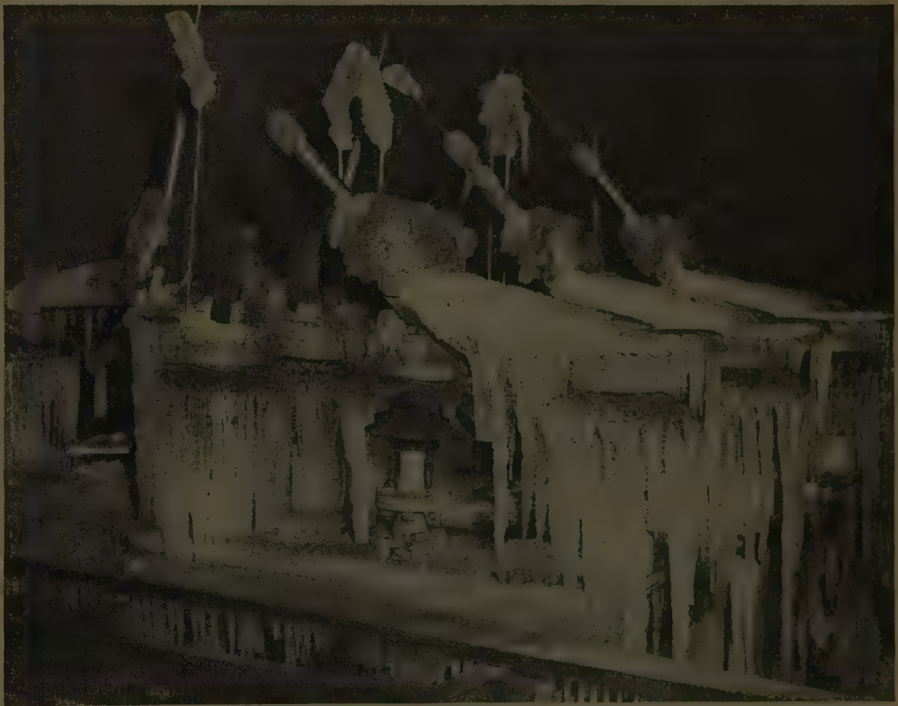

Figure 4. Close-up view of switch pole units with each switch in an intermediate position after being operated

DESIGN FEATURES

DEVELOPING the ice tests described in this article, a great mber of tests were made on a va- ty of switches, and certan desir- e features of design for ice- aking switches were determined e Figure 5).

An ideal design for an air switch perate when covered with ice is in which all moving parts are to- y enclosed and cannot accum- te ice. Obviously, a practical ign cannot enclose the blade and ak jaw, and there is a need for iliary blade motion to break ice the jaw. Many such motions e been devised, one of the most ular being a blade twisting mo- h that takes place before blade begins. In general, this motion ery effective in clearing the jaw ce, provided the mechanism used to obtain the blade tion does not itself become fouled with ice. It is pos- e to design a mechanism which is itself entirely en- ed and protected from icing; such a mechanism is cribed by H. W. Graybill and J. S. Ferguson.[1] This chanism is employed in the switch described here. Thus, the first feature of switches which have been designed to work under ice conditions should be an enclosed-blade actuating mechanism.

The tests which have been described revealed further that the hinge-end contact was another source of difficulty under ice conditions. Switches were tested which had jaw contacts at the hinge, similar to those used at the break end. These hinge jaws gathered ice and increased the initial effort required to start the switch moving. Switches which have totally enclosed hinge contacts showed a considerable reduction in operating effort under ice conditions of the test.

It also was made apparent during the testing of these switches that adjacent switch parts with relative motion should be widely spaced. Any flat surface which was required to move with respect to a closely adjacent parallel stationary surface was particularly troublesome. Ice bridging between these surfaces was very difficult to break. Therefore, a third feature of ice-breaking switches is to design the switches so that they have freedom from closely spaced parallel surfaces which have relative motion during switch operation.

Figure 6 shows a pole unit of a switch which was especially designed to operate under the most severe ice coatings, and which incorporates all of the features which were found to be desirable in the testing program described here.

SUMMARY

At present, there is no standardized method of testing outdoor air switches to evaluate their performance when covered with ice. A careful study has been made of the problem of producing ice in artificially cooled rooms which corresponds in density and strength of bonding with that encountered in service. The essential elements of a testing procedure to give the desired results are as follows:

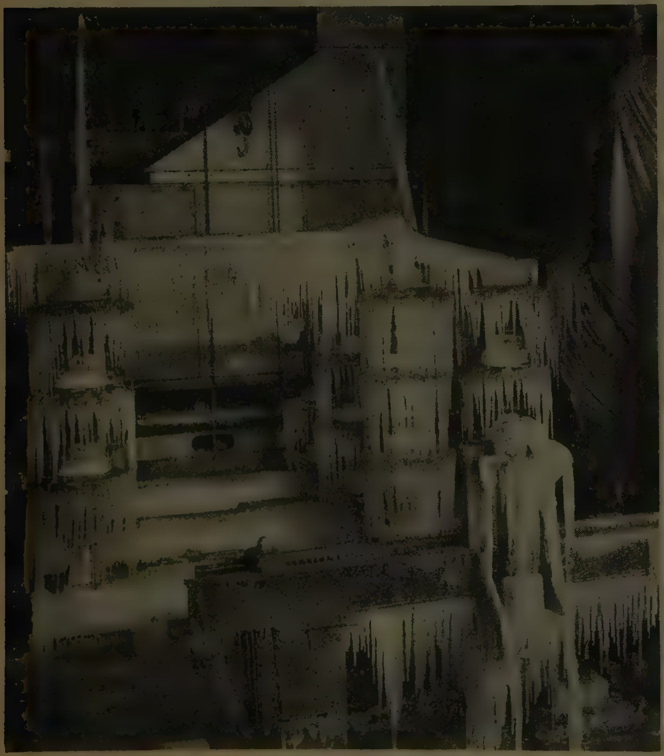

Figure 5. Setup for testing the performance of 115-kv 1,200-ampere switches

1. A complete switch is assembled for normal operatio and all traces of oil or grease are cleaned from switc surfaces.

2. The air temperature is lowered to 35 degrees Fahrenheit and a general rain of water which has been precoole to 35 degrees Fahrenheit is started.

3. After the rain has been started, the air temperatu is lowered approximately 3 degrees Fahrenheit per hou until a final temperature of 25 degrees Fahrenheit has bee reached.

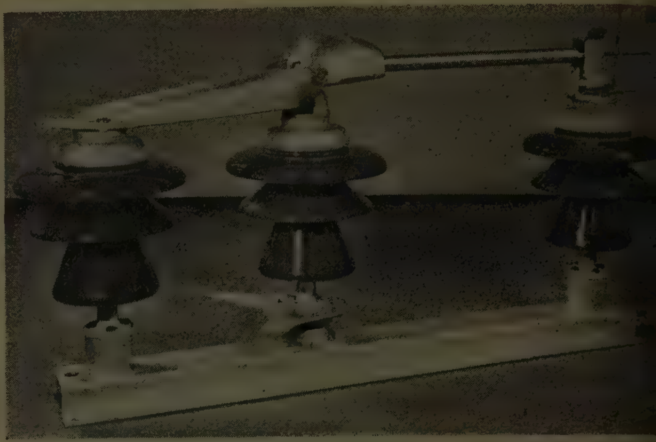

Figure 6. Pole unit of a switch especially designed to have goo performance under heavy ice coatings

4. The rain is continued with the air temperature 25 degrees until an ice thickness of one inch has bee reached on the top of the switch blade or on a horizont conductor receiving the same rain as the switch.

5. The switch is operated and the operating effo noted.

During the testing of many switches using these spec fications, certain important features of design for ic breaking switches were determined. These features a as follows:

1. An auxiliary ice-breaking motion should be imparte to the blade before blade rise begins. The mechanis which imparts this motion to the blade should be enclose and protected from ice accumulations in both open a closed positions.

2. The hinge-end electrical contacts should be pr tected from ice accumulation.

3. Closely spaced parallel parts which have relati motion during switch operation should be avoided in a cases.

It is suggested that the testing method developed considered as a standard procedure for outdoor swit testing.

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Finite Representation of Impulse Functions

J. J. SMITH
MEMBER AIEE

P. L. ALGER
FELLOW AIEE

RANSIENT PROBLEMS, such as closing a switch at a certain time, or throwing a load on a machine ddenly, or applying an impulse to a system, involve the e of discontinuous functions. These may be expressed in e type of notation by multiplying any given function by e Heaviside Null Unit Function $H(x,x_0)$, which is equal zero when $x<x_0$ and is equal to unity when $x>x_0$. Simi-ly, in studying the fields due to point sources in a con-uous medium the impulse function which is the deriva-e of the Null Unit Function $H'(x,x_0)$ arises.

Until the recent development of Schwartz[1,2] no accepted thematical method was available for handling such antities as $H'(x,x_0)$ and its higher derivatives in a direct nner, although, as Schwartz points out, engineers and ysicists had been dealing with such problems by methods their own such as the operational calculus. In a 1949 per[3] it was indicated how Schwartz's method could be plied successfully to such quantities when they arose in solution of problems. In the same paper the solution the same problems was given using $H'(x,x_0)$, $H''(x,x_0)$... a formal manner.

Although the practical application of the Schwartz thod has already been shown,[3] the theory on which it based is somewhat advanced and this seems a deterrent its exploitation to the fullest extent by engineers. A pler method is to use differentials $d^nH(x,x_0)$ instead of ferential coefficients $d^nH(x,x_0)/dx^n$ following the pattern d previously in the Stieltjes integral.

This procedure may be visualized by referring to Figure In (*a*) the unit function $H(x,x_0)$ is shown, with a finite continuity equal to unity, at $x=x_0$. This graph is drawn 'unit" space, with ordinates plotted in finite units. In is shown a common conception of the derivative $x,x_0)/dx$, also in unit or function space. This is zero ept at x_0, where it becomes infinite in such a way that area of the "spike" representing it is equal to unity. (*c*) a representation of $dH(x,x_0)$ is shown which is zero rywhere except at $x=x_0$ where it is equal to 1, or equiva- to a unit mass. It will be noted that this might be rded as representing a compression of (*b*) in "Δx e" obtained by simply multiplying all the ordinates of by dx. This scale reduction converts the infinite ear) ordinate of (*b*) at $x=x_0$ to a unity (mass) ordinate *c*).

ence, by this simple expedient of transforming into space, with all ordinates reduced from reality by the tiplier dx, the representation of $H'(x,x_0)$ has a finite, in-d of an infinite, value at $x=x_0$.

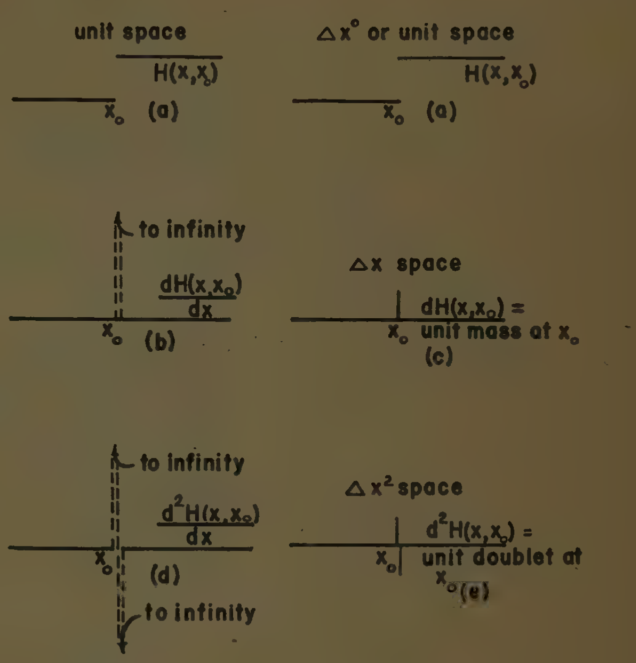

Figure 1. Null Unit Function and its first two derivatives in unit space and in Δx space

Evidently the same procedure, carried one step farther, into Δx^2 space, will make $d^2H(x,x_0)=dH(x,x_0)-dH(x-\Delta x,x_0)$. This may be regarded as a unit doublet, as shown in Figure 1(*e*). The usual representation of the second derivative $d^2H(x,x_0)/dx^2$ by two infinite plus and minus spikes, Figure 1(*d*), is compressed into the unit doublet by multiplying the unit space ordinates by dx^2.

For the case of the *n*th order it is readily shown

$$d^nH(x,x_0)=\sum_{r=1}^{r=n}(-1)^{r-1}\frac{(n-1)!}{r!}dH(x-(r-1)\Delta x,x_0)$$

and this can be interpreted as a unit *n*-tuplet at the point x_0 similar to the doublet above in the case of $d^2H(x,x_0)$. The *n*th derivative of $H(x,x_0)$ is obtained by dividing each side of the equation by dx^n.

In this way, equations including impulse functions can be rendered finite, permitting their solution by conventional methods but requiring that the equations hold in each of the Δx^n spaces involved.

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mith and **P. L. Alger** are both with the General Electric Company, Schenectady,

A Simple Magnetic Modulator for Conversio of Millivolt D-C Signals

GUNNAR WENNERBERG

Saturable reactors now are being used in magnetic amplifiers because they are capable of handling larger loads than vacuum tubes can and they have stable performance when converting d-c signals to alternating. Presented here is a design of a magnetic modulator in a control system which is otherwise entirely electronic.

VARIOUS forms of saturable reactors are taking their place along with other basic circuit components, such as vacuum tubes, thyratrons, amplidynes, and so forth, at an increasing rate. Recently the so-called self-saturating type of magnetic amplifier circuit has drawn considerable attention[2–5] primarily due to its high gain characteristics.

The reasons for substitution of the magnetic devices for other types of amplifiers are well known. However, it is of great importance to examine the characteristics of the various forms of magnetic amplifiers purely from a performance standpoint, aside from service life, reliability, and other features, and to have a clear picture of those functions in which the magnetic devices can give superior performance.

It is found that saturable reactors have two interesting capabilities:

1. Capability of handling larger current and power than conveniently can be handled by the use of electron tubes.
2. Capability of converting low-voltage d-c signals into alternating current with a high degree of stability.

This article will discuss some aspects of the latter category of application.

Emphasis on these fields is increased by the demands which the high-gain-type magnetic amplifier circuits put on the associated rectifiers. These are often difficult to meet when a high degree of stability and linearity is required under adverse environmental conditions, such as are encountered in aircraft applications, for instance. In such cases it is often practical to use tube rectifiers.

As there is no appreciable difference between the reliability of a diode and that of a triode, it is sometimes thought that, as long as tubes have to be used in the circuit, one may as well utilize their gain, that is, in effect, use the vacuum tubes as grid-controlled rectifiers. The power gain in the magnetic amplifiers then becomes less important, while the possibilities they offer for the solution of such problems as are imposed, for instance, by signal sources like thermocouples, is of great value.

When gain is sacrificed, the performance of the magnetic amplifiers in other respects, such as linearity and speed response, can be greatly improved. At the same tim simplifications of the magnetic amplifier circuit itself ca often be made. The demands on the magnetic materi also become different. Particularly high saturation flu density, for instance, is n necessary. On the other han the use of gapless cores be comes even more imperativ The lowered requiremen for saturation flux densit open possibilities to use co materials of the new, prac tically nonconductive ferr magnetic-spinel type. Th ferromagnetic-spinel core also have been found to b advantageous from a mechanical viewpoint, becaus they are not sensitive to handling as ordinary nickel-iro alloys are.

The viewpoints given here grew out of the design of magnetic modulator to meet a specific need in an otherwis electronic control system.

The problem was to derive an a-c signal of the suppl frequency, sinusoidal shape, constant phase, and with a amplitude proportional to the input, from a d-c signal wit a maximum value of the order of 100 millivolts at a impedance of 1,000 ohms. The phase of the output voltag was to reverse as the polarity of the input signal reverse

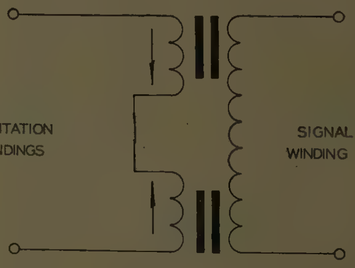

Figure 1. Schemat diagram of the bas modulating unit

Main emphasis was to be laid upon linearity, noncritica operation as to variations in supply voltages, adaptabilit to existing parts of the control system, general simplicit and smallest possible size and weight.

In order to meet the requirement of a sinusoidal outpu of constant phase, it is necessary to operate over a sma portion of the magnetization curve, in contrast to the high excitation thyratron-like operation that is normally use in high-gain magnetic amplifiers.[3,9]

Traditionally, a magnetic amplifier of the push-pull

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Gunnar Wennerberg is with Lear, Inc., LearCal Division, Los Angeles, Calif.

ance-detector type that is indicated here consists of four es, equipped with three or four windings each, or the ivalent thereof in the form of a pair of 3-legged reactors. some re-examination of the various needs of excitation, s, and so forth, in the light of the general circuitry ired, available power sources, and possible short cuts the particular case, it was found that a considerable plification could be made.

The basic saturating unit finally chosen is shown ematically in Figure 1. An actually constructed unit llustrated in Figure 2, under various stages of completion. e arrangement consists of only two saturable cores and otal of three windings. The principle of operation is cribed briefly: the two cores are excited by the same rent and in opposite directions, so that no net voltage induced in the signal winding. This symmetrical ndition will be maintained even if a d-c component is led to the a-c excitation current, as the two cores still, every moment, will be subject to a magnetizing force of al strength but opposite sign.

f now a direct current is introduced in the control nding, the symmetry is disturbed and a voltage is induced this winding. If the excitation current is pure alternat- current, the induced voltage will consist of even harics of the excitation frequency. If a direct bias current dded, the induced voltage will consist mainly of the amental frequency.

re 2. Magnetic modulator in various stages of completion. to right: a single core with excitation winding; a matched pair, ready for signal winding; a completely wound unit; a finished unit, magnetically shielded and hermetically sealed

few possible application circuits for the device illused in Figures 1 and 2 are shown in Figure 3. Either s or parallel connections of the reactor, relative to the al path, are possible. The circuit finally chosen for solution of the specific problem mentioned previously e series-connected type, with biased operation, Figure The practical advantages of the 2-core magnetic ulator can be summarized as follows:

In order to simplify the procedure of matching cores, it is highly desirable to reduce the number of saturable cores to a minimum.

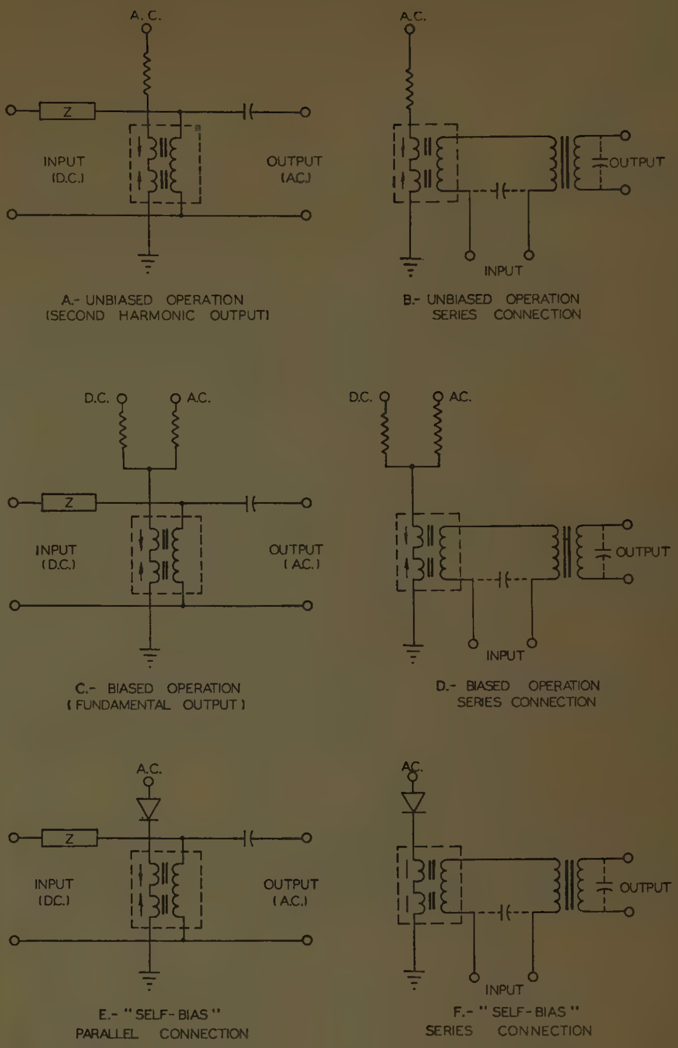

A.C.
Z
INPUT (D.C.)
OUTPUT (AC.)
A.- UNBIASED OPERATION (SECOND HARMONIC OUTPUT)
A.C.
OUTPUT
INPUT
B.- UNBIASED OPERATION SERIES CONNECTION
D.C.
A.C.
Z
INPUT (D.C.)
OUTPUT (A.C.)
C.- BIASED OPERATION (FUNDAMENTAL OUTPUT)
D.C.
A.C.
OUTPUT
INPUT
D.- BIASED OPERATION SERIES CONNECTION
A.C.
Z
INPUT (D.C.)
OUTPUT (A.C.)
E.- "SELF-BIAS" PARALLEL CONNECTION
A.C.
OUTPUT
INPUT
F.- "SELF-BIAS" SERIES CONNECTION

Figure 3. Magnetic modulator circuits using the basic modulating unit

2. In order to avoid any dependence of the balance upon any winding resistance values, it is desirable to transmit the energy from the excitation source purely through flux linkages, and to connect all excitation windings in series.

3. In order to obtain the largest possible number of control ampere turns, it is desirable to use the largest possible portion of the winding space for the control winding.

4. When a sinusoidal output current is desired, it has been found preferable to excite the modulator with a constant alternating current, rather than exciting it by a given voltage.

The various modes of operation are illustrated by the magnetization curves of Figure 4. The curves shown represent an idealized case, taking only the commutation curves into consideration. Major, as well as minor, hysteresis loops are disregarded for the sake of simplicity of reasoning.

The operation in the biased case, which perhaps is of the greatest practical interest, is shown in Figures 4*A* and 4*B*.

As indicated, the cores are excited with a given current rather than with a given voltage, and work over only a relatively small portion of the magnetization curve. In the case where no loading is present in the output circuit, Figure 4*A*, the output voltage is derived simply as the time derivative of the differential flux wave. In order to make this wave reasonably sinusoidal, it would be necessary to work over such a small portion of the magnetization curve that it can be approximated as a straight line, even at its maximum curvature. This mode of operation gives very low output and often causes difficulties due to hysteresis, as the excitation may not be big enough to allow the signal to move the working points without showing the effects of hysteresis.

As far as linearity is concerned, an interesting improvement occurs if the output circuit is heavily loaded. In order to illustrate the effect, the highly idealized case of completely short-circuited output is pictured in Figure 4*B*. At short-circuited condition no net differential flux can occur, as any change in flux would give rise to a voltage and consequently to a counteracting current. From this observation it can be derived that the short-circuit current has to counteract the excitation ampere-turns in one of the cores and increase them in the other to such an extent that the differential flux becomes zero. This has some interesting effects. First, the core where signal and bias ampere-turns are counteracting each other gets its net a-c magnetization reduced. This greatly reduces harmonics output that otherwise should appear because of the increased curvature at the working point. At the same time the other core gets its net excitation increased by the same amount, making the curvature of its working range very nearly the same as that of the other core. If this is to be accomplished exactly, the magnetization curve has to be part of a logarithmic curve. The ratio between excitation and output currents then becomes at every moment constant. Consequently they have to be of the same wave shape.

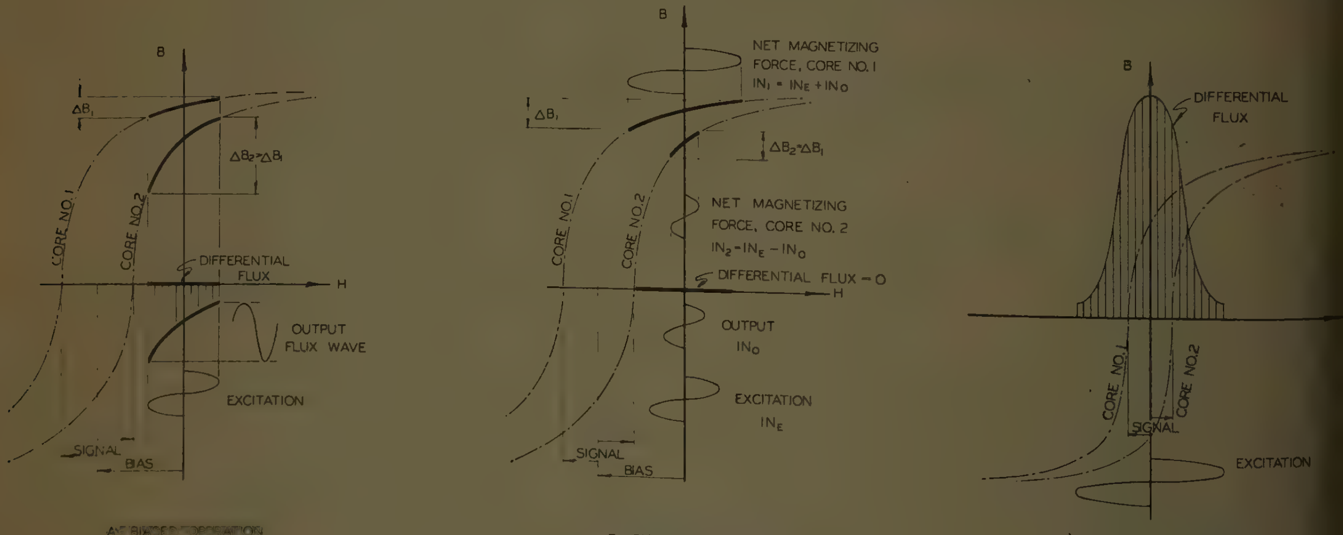
The interesting conclusion is then reached that under these circumstances sinusoidal excitation current gi rise to a sinusoidal short-circuit current, which is exac in or out of phase with the excitation current; this occu in spite of the nonlinear properties of the magnetic m terial. In accordance therewith, it has been found expe mentally that the excitation current can be increas substantially before visible distortion occurs when t output circuit is heavily loaded. In fact, when ferr magnetic-spinel core materials are used, this mode operation has been found to be the only practical one wh a sine wave output is desired, because of the relatively lar hysteresis effect these materials exhibit when they are su jected to excitation.

It should be noted that the action of a short-circuit magnetic modulator, in certain respects, is very similar that of a current transformer. The output current is, f instance, proportional to the excitation current, but the ou put ampere-turns are not necessarily equal to the signal an pere-turns, as is the case in a normal, highly saturated r actor without feedback.[9] However, in practice it has bee possible to obtain a linear relationship between the sign and output currents that is at least as good as the readin accuracy which is available on most ordinary laborato meters.

For comparison, the magnetization curves for the u biased case are shown in Figure 4*C*. This mode of oper tion is recommended where the best possible sensitivity required, demands on linearity are not too high, and t frequency doubling from excitation to output can tolerated.

The demands on the uniformity of the two magnet cores in the described case differ from those of ordina highly saturated operation in the respect that balance required over the entire knee of the magnetization curv In the highly saturated case usually considerable toleran can be allowed on the steep portion of the curve, whi the saturation flux has to be very nearly equal in t individual cores.

In order to satisfy the matching requirement in th



A.- BIASED OPERATION
NO LOAD CONDITION

B.- BIASED OPERATION
SHORT CIRCUIT CONDITION

C.- UNBIASED OPERATION
NO LOAD CONDITION

Figure 4. Magnetization curves showing the various modes of operation of the modulating unit

e it has been found imperative to use gapless cores. e toroidal shape was selected because of its maximum npactness for a desired performance. A laboratory ip for matching cores is shown in Figure 5. About cores, with excitation windings put on, are threaded on opper bar, forming a common 1-turn secondary. The erential voltage is measured when the cores are excited h the same bias and somewhat larger alternating current n they are intended to be used for, and the best pairs selected.

typical measured performance curve for a finished t meeting the specification given in the beginning is wn in Figure 6. The core material in this particular e was a ferromagnetic spinel. As the wave form of the put voltage does not change appreciably with the hal strength, the linearity is equally good for the average rms values or the fundamental sine wave of the output tage.

The output current was found to be proportional to the itation, while the variation in output for normal varians in bias current was smaller than a proportional ntity.

The property of having an output proportional to the itation is shared by the magnetic modulator with several ds of pickoffs commonly used in control systems, such potentiometers, inductive pickoffs, and so forth. There-, this property is sometimes an advantage. If, for exple, the output of a thermocouple has to be compared hat of a potentiometer, which is fed from the same line he magnetic modulator, compensation for line-voltage ation is automatically achieved.

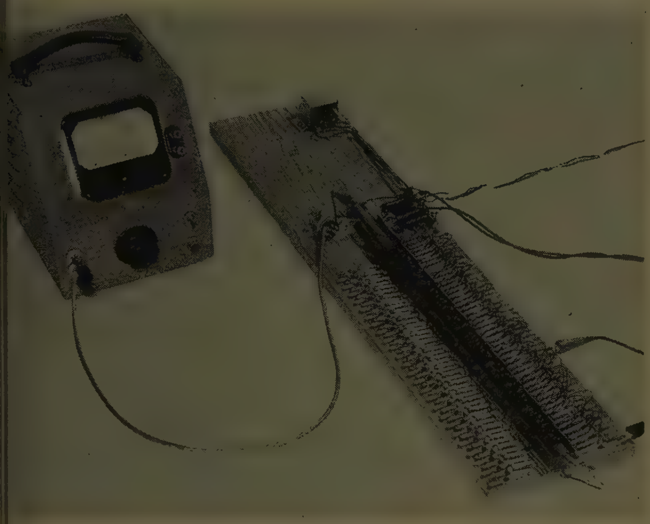


Figure 5. Laboratory setup for core matching

The performance illustrated in Figure 6 does not repre- the ultimate possible sensitivity. In the written dision to papers by A. G. Milnes[4] and H. M. Gale and D. Atkinson,[5] J. F. Coales has given a tabulation of ous properties of the different kinds of amplifiers ploying a modulated magnetic field. The input stability l is listed as from 10^{-6} all the way down to 10^{-17} watts.

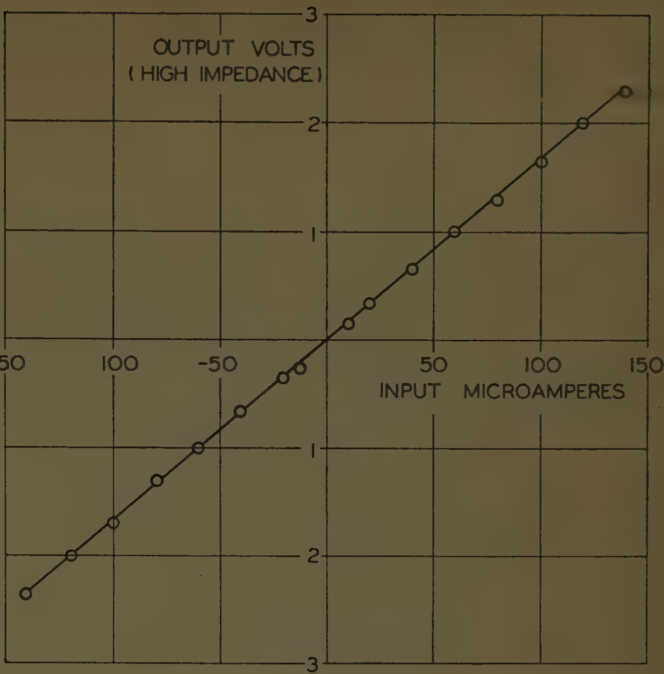


Figure 6. Typical measured performance curve for 1,000-ohm magnetic modulator in biased operation (schematic of Figure 3D)

The latter figure is obtained with an arrangement giving even harmonics output. These figures are indicative of possible applications of magnetic modulators in the small signal field.

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An Improved Transmitted Carrier System

G. H. BRODIE

WHEN, following World War II, the use of telephone carrier circuits became widespread on independent telephone lines of short and medium electrical lengths, manufacturers followed the practice previously established on long-line applications and supplied suppressed carrier equipment.

Such equipment, while generally satisfactory from a technical viewpoint, sometimes imposes hardship on small independent companies where suitably trained technicians are not always available. A telephone carrier system in which the carrier is transmitted offers several advantages to the independent telephone field, providing it is so designed and constructed that technical disadvantages usually associated with the transmission of the carrier are minimized or eliminated.

Compared with a typical suppressed carrier system, the chief advantages offered by a transmitted carrier system of suitable design and construction are as follows:

1. Neither synchronization of local and distant oscillators nor critical carrier leak adjustments are required.
2. The carrier-frequency signal can be traced through the entire system and measured easily when the channel is either in use or idle.
3. Ringdown signaling can be accomplished in a very simple and inexpensive manner.
4. Receiving oscillators are not required.
5. Voice-frequency shift is completely eliminated.
6. Neither additional pilot frequencies nor extra bands for signaling or dialing are required.
7. The basis for an automatic circuit failure alarm is provided.
8. A simple method of modulation, without use of transformers, is made possible.
9. Installation, testing, and maintenance are greatly simplified.

To obtain these advantages and, at the same time, to avoid, or at least minimize, the difficulties which may arise from the transmission of several carrier frequencies at relatively high levels, particularly careful attention must be given to many problems in engineering design.

In the case of the type-*5* stackable 1-, 2-, or 3-channel carrier system described here, the manner in which some of these problems were solved may be of interest.

The carrier frequencies were chosen in such a manner that any sum or difference frequency which might be generated would fall outside of the carrier bands and outside of the normal telephone voice-frequency range. These carrier frequencies are 7.150, 10.725, 14.300, 21.450, 28.600, and 35.750 kc. The upper sideband is transmitted with the 14.300-kc carrier while the lower sideband is employed with all of the others.

Exceptionally good frequency stability is attained through the use of stabilized toroidal inductors with very lo negative-coefficient ceramic capacitors in suitable circuit Final frequency adjustment is made with a small air-d electric variable capacitor.

Intermodulation is held to very low levels in the filte through the use, where required, of physically large low permeability dust-core toroids or air-core inductors. Th carrier-frequency repeating coil, which may be called upo to pass all transmitted and received carriers simultaneousl has a core of generous cross section built up with thi laminations of Mu-metal. When properly wound wit sufficient turns of wire in each winding, a coil of this typ maintains constant inductance over a considerable range applied voltage and thus produces a minimum of intermodulation products.

To prevent crosstalk in the presence of transmitted carriers at relatively high levels, the band filters are designe to provide attenuations of 80 decibels or more, outside the passband. Rejection notches are provided at th frequencies of other carriers which might be particularl troublesome if allowed to enter.

To minimize any possible interference with other carrie systems on the same pole line, the transmitted carrier frequencies of the type-*5* system can be partially suppresse at the transmitter and differentially amplified at the receiver. The addition of simple tuned circuits at eac terminal makes this possible. Up to this time no necessit for this treatment has been encountered.

Physically, each terminal of this carrier system consist of panel mounted units assembled on a standard 19-inc rack. Rack space for a single channel terminal complet with signal unit and power supply is $22^{3}/_{4}$ inches. Fo the complete 3-channel terminal either $47^{1}/_{4}$ inches o $54^{1}/_{4}$ inches of rack space are required, depending o whether one or two power supply units are employed.

The first channel uses no power amplification and transmits at a maximum level of 10 decibels above one milliwat The second and third channels employ power amplifier and are capable of transmission at levels up to 20 decibel above one milliwatt. The available over-all gain is approximately 23 decibels for the first channel and 35 decibel for the second and third channels. With these values gain and transmission, performance, measured in miles typical line, is approximately equal for the first and secon channels, with the third channel dropping from 12.5 30 per cent.

Each of approximately 300 of these transmitted carrie systems, installed in various sections of the country, giving satisfactory service with a minimum of maintenanc

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Digest of paper 50-241, "An Improved Transmitted Carrier System for Telepho Lines of Short or Medium Length," recommended by the AIEE Committee on W Communication Systems and approved by the AIEE Technical Program Committ for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., Octob 23–27, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

G. H. Brodie is with the Kellogg Switchboard and Supply Company, Chicago, Ill.

Tank Pressure Variation in Sealed Transformers

E. W. TIPTON
MEMBER AIEE

A modern power transformer only the insulation, oil, and fibrous materials, show appreciable deterioration ler normal operating conditions. Consequently, it is y natural that much effort has been applied to the blem of preventing or retarding this deterioration. ny schemes for this purpose have been devised; open breather, dehydrating breather, conservators, gas-oil s, sealed tanks, inert gas atmospheres, and thermo- ion clay filters are examples. These devices have one wo objectives: to prevent the entrance or to minimize effects of moisture, or to exclude oxygen and minimize effects of oxidation. The simplest and one of the most ctive methods is to seal the transformer tank.

Vhen a transformer is tightly sealed with a gas space r the top of the oil surface, it is subject to variation in rnal pressure during its operating cycle. Changes in perature due to ambient changes and to heating from tation and load losses cause the oil to expand, and duce heating of the gas. Both effects result in an ease in internal tank pressure. The variation of ssure as a function of load and ambient temperature is nterest, both to transformer designers and operators.

he calculation of pressure as a function of load is not a ple one. The principal factors involved are: oil ansion due to heating, pressure temperature effects on tank wall deflection, solubility of the gas in trans- ner oil, and chemical reactions between the gas and sformer oil. The effects of the first two of these ors may be easily and accurately calculated. Tank deflection is a relatively minor, though appreciable, or, and it can be estimated empirically from test results fair accuracy. Gas solubility and reaction with sformer oil are difficult to calculate, but they play major role in determining transformer pressure.

tandard temperature run tests made on a 500-kva sformer gave data which lead to these conclusions:

With standard rectangular tanks the effect of tank deflection is to decrease the measured pressures below calculated values by approximately 15 per cent.

With commercial methods of processing, a trans- ner, as delivered for use, will have a load pressure racteristic greatly different from that calculated by the laws. This is true whether the transformer is or is filled under vacuum. In both cases, under rated , the maximum pressure will be reached before constant perature is attained and the pressure will be lower than calculated by the gas laws. Vacuum-filled trans- ners have lower pressures than those which are not.

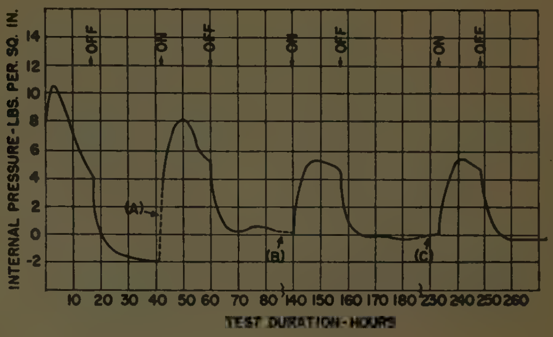

Figure 1. Time pressure curve. Oil filled under vacuum and sealed at atmospheric pressure. Repeated load cycles. Air in the gas space

3. When vacuum filled, if allowed to stand open for 24 hours before sealing, the results are about the same as when the transformer is sealed immediately. The gas does not quickly go into solution at ambient temperature with nonagitated oil.

4. As illustrated by Figure 1, in a vacuum-filled transformer the load pressure characteristic stabilizes after about one full load temperature test cycle. The average oil temperature varied from 20 degrees centigrade to 65 degrees centigrade and the transformer had a gas-to-oil ratio of 13.75 per cent.

5. After a transformer is vacuum filled, a considerable amount of gas must be added under pressure while the oil is hot before the oil becomes saturated with gas. In these tests, the oil dissolved about $12^1/_2$ per cent of nitrogen by volume corrected to 25 degrees centigrade and atmospheric pressure.

6. If negative pressures are to be avoided in sealed transformers, it is necessary to restore gas which is removed by vacuum filling of the transformer. This gas is not easily restored. One suggested method is to charge the gas space with dry nitrogen at a positive pressure of from six to eight pounds per square inch before it is placed in operation. This charge then should be repeated once or twice after the transformer has undergone a load cycle. This practice is safe only if the tank is protected with a relief valve set to operate at a pressure a little lower than the tank test pressure.

7. Another and simpler method of restoring gas to the oil is to provide the transformer with a relief valve to relieve excess external pressure. During normal operation, after a few temperature extremes, sufficient air is admitted to saturate the oil to the extent that thereafter no further adjustment will take place. The amount of oxygen admitted is too small to adversely affect the oil properties.

8. Once the oil is saturated with gas and sealed, the operating pressure range will be in the order of 80 to 85 per cent of that calculated by the gas laws.

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of paper **50-275**, "Variations of Tank Pressure with Transformer Loading in Transformers," recommended by the AIEE Committee on Transformers and ved by the AIEE Technical Program Committee for presentation at the AIEE General Meeting, Oklahoma City, Okla., October 23–27, 1950. Scheduled for ation in AIEE *Transactions*, volume 69, 1950.

Tipton is with the Westinghouse Electric Corporation, Sharon, Pa.

Measurement of Insulation Resistance on Energized Systems

E. L. BRANCATO
MEMBER AIEE

A. T. McCLINTON
MEMBER AIEE

An instrument has been developed to measure the insulation resistance of either an a-c or d-c system without removing the system from operation. The present voltmeter method of performing this operation involves the taking of a number of readings and applying these to a formula, but the new instrument makes it possible to get the information which is desired directly.

INSULATION resistance measurement of electric equipment gives an indication of the condition of the electrical insulation through a measurement of the current leakage through and/or over the surface of the insulation. These leakage currents are influenced by the dielectric state of the insulation and by the presence of moisture and other contaminants; therefore, a measure of the insulation resistance of electric equipment or of a system assists greatly in determining the safety and reliability of the equipment for operation.

The insulation of electric systems of vessels tends to deteriorate with time, owing to the abundance of moisture and salt that saturates the surrounding atmosphere. This tendency, if not checked, will result in establishing one or more low-resistance paths between the system and ground. This condition may endanger the operation of the electric plant, personnel, and possibly the safety of a shi when electrically propelle Thus it is important that th system insulation resistanc be observed continuously s that deterioration of insulation resistance can be checke to prevent the establishmen of grounds.

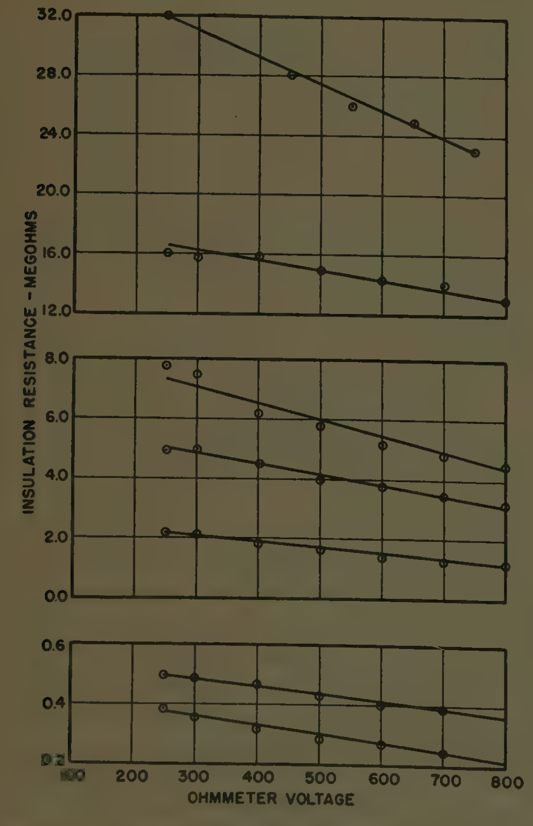

Figure 1. Effect of ohmmeter voltage on insulation

This resistance can be easily and directly measured b a Megger or other suitable ohmmeters. Their use, however, entails the de-energization of the system during th period of measurements. It is evident that this procedur is not feasible generally and is impossible where continuit of service is necessary.

At present the voltmeter method is employed on energized d-c systems. This consists in measuring with voltmeter of known internal resistance the system voltage from each line to ground, and across both lines. Th three voltage readings and meter resistance are applie to a simple formula which permits calculation of syste insulation resistance. This method suffers from a numbe of shortcomings, namely, involved procedure of multipl measurements and calculations, inaccuracies due to variation in system voltage while obtaining voltmeter readings and insensitivity of the voltmeter when the insulatio resistance is high. It is apparent that this procedure i laborious and indirect, and it does not provide the accurac that can be obtained from measurements on de-energize systems.

BASIC CONCEPTS

A CONSIDERATION of the problems involved with presently employed insulation resistance measurin devices on shipboard, an analysis of operational problems and a study of insulation characteristics suggest that th requirements for a ground detector are that it shall contai its own source of voltage for stressing the insulation, an that it provides a direct reading with simplicity of operatio

The first requirement is satisfied by an electrically isolate rectifier-type power supply. The magnitude of its voltag should be approximately equal to the potential of th system to be measured. The importance of prope selection of this voltage has been demonstrated by S Evershed[1] and is further illustrated in Figure 1. Th

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Full text of paper 501-94, "Measurement of Insulation Resistance on Energized Systems," recommended by the AIEE Committee on Rotating Machinery and approve by the AIEE Technical Program Committee for presentation at the AIEE Middl Eastern District Meeting, Baltimore, Md., October 3–5, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

E. L. Brancato and A. T. McClinton are with the Naval Research Laboratory, Washington, D. C.

luence of voltage, varying from 250 to 800 volts (ohm-ıter open-circuit voltage), upon observed insulation istance of electric systems ranging from 0.2 to 20 meg-ms is depicted. It becomes evident that the application a voltage stress lower than the system normally ex-riences would result in an unrealistic measure of insula-n resistance whereas the use of a voltage stress higher an system voltage may result in insulation breakdown.[2]

The second requirement can be met through the use of ohmmeter type of instrument. Such an instrument uld utilize a ratio-type meter movement, as employed a Megger, or could consist of a constant-potential supply d a microammeter or a milliammeter with a scale librated for resistance. In order to employ such a device a 2-wire ungrounded d-c system it is necessary to be able select some point at which the potential of the ohm-ter circuit can be impressed on the ctric system. This point must be selected that no additional potential is injected o the measuring circuit.

The basic circuit for meeting this second quirement is illustrated in Figure 2. In s circuit R_A and R_B represent the dis-buted resistance of each line to ground the associated circuit. The potentiom-r connected between points l and m ovides a means whereby a point of zero tential, namely that between G and S, can obtained. This is obtained when the der of the potentiometer is adjusted to e the relationship

$$\frac{R_x}{-R_x}=\frac{R_A}{R_B} \qquad (1)$$

Thus a point of zero potential has been tained for insertion of the measuring trument. However, the presence of the entiometer will cause an error as given the equation

$$\text{or in ohms}=\frac{R_x(R-R_x)}{R} \qquad (2)$$

ere R is the total resistance of the poten-meter. It should be noted that this error dependent only on the potentiometer and lependent of the insulation resistance. this error is expressed in terms of the ctional distance x of the slider from l it comes

$$\text{or}=x(l-x)R \qquad (3)$$

e relationship is plotted in Figure 3. his applies only to a linear potentiometer.) is evident from equation 3 that the error be diminished by reducing the resistance ue of the potentiometer; however, the luction of this resistance is limited by practical consideration of energy dissi-ion in the potentiometer. For example, a 700-volt system a 10,000-ohm potentiometer rated 50 watts must be used. Since the reduction of potentiometer resistance to a very low value is impractical, compensation for the error was resorted to. The error, being a variable quantity, was not easily compensated alone. However, putting a second potentiometer in series with the balancing potentiometer produces a total error which is constant; that is, independent of slider position.

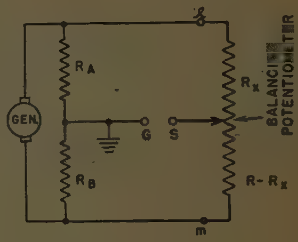


Figure 2. Basic circuit of the ground detector

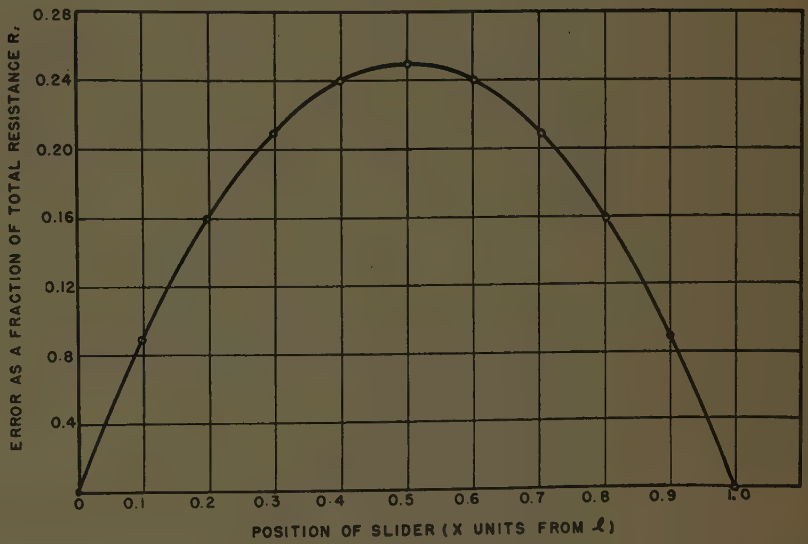


Figure 3. Error produced by a balancing potentiometer in the basic circuit

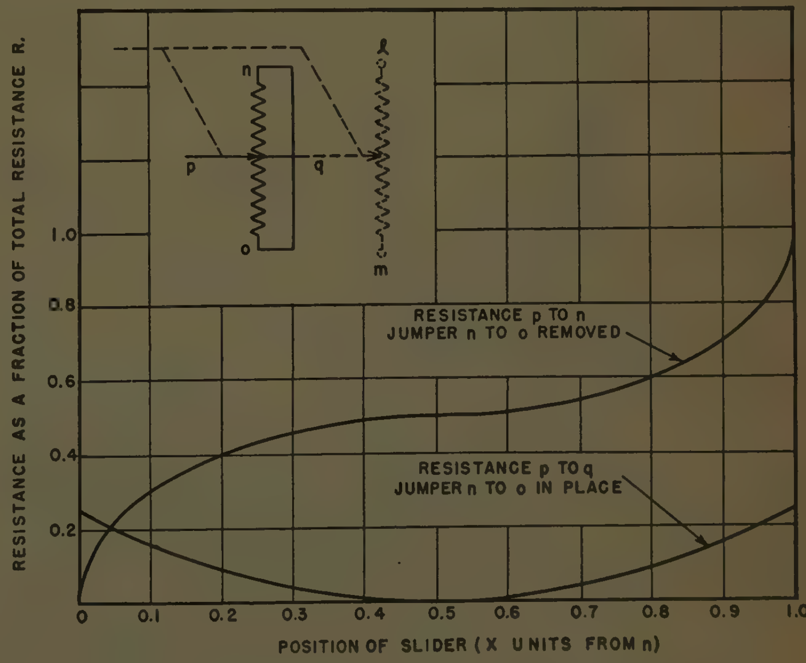


Figure 4. Characteristics of compensating potentiometer

This error then could be compensated by removing the corresponding amount of resistance from the internal circuit of the measuring instrument.

The resistance at the terminals of the compensating potentiometer, if R_{comp} is allowed to have its minimum possible value, must be given by the equation

$$R_{comp}=[0.25-x(l-x)]R \tag{4}$$

where R is the total resistance of the balancing potentiometer. A nonlinear potentiometer having this characteristic was connected electrically in series with the balancing potentiometer, with the shafts of the two potentiometers mechanically coupled. The characteristics of th and the connections ar shown in Figure 4.

DESCRIPTION OF THE GROUND DETECTOR

It becomes evident that operation of a device employin the aforementioned principles requires (1) a circuit t detect the unbalanced voltage between the slider of th balancing potentiometer and ground, and (2) a means o driving the balancing potentiometer to the point of zer potential or null point. Two methods have been develope for performing this operation. The first utilizes a volt

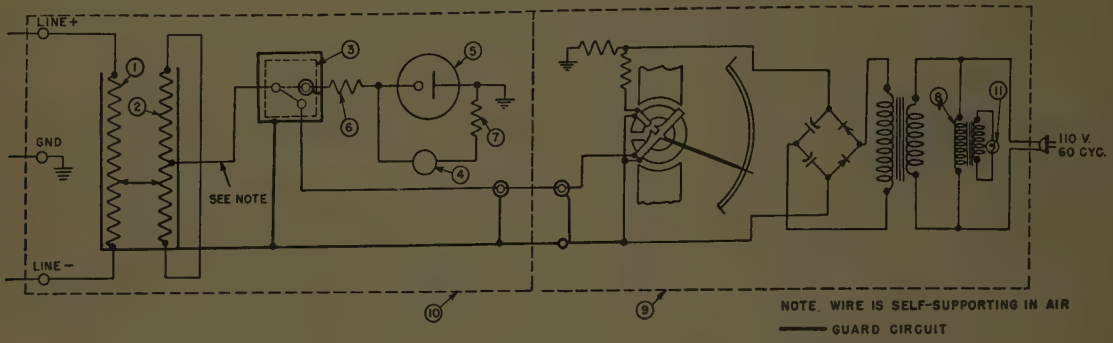


Figure 5. Schematic diagram of the ground detector

1—Balancing potentiometer, 10,000 ohms, 50 watts
2—Compensating potentiometer, 10,000 ohms, center tapped, taper wound
3—Galvanometer switch, push-button type, single-pole, single-throw. Normally closed on ohmmeter circuit
4—Galvanometer center "0", 50 microamperes
5—Neon tube, 115 volts, 2.5 watts
6—Resistor, 0.25 megohm, 3 watts
7—Resistor, 1 megohm, 2 watts
8—Transformer, NRL 4210, 115/6 volts, 0.15 ampere
9—500-volt ohmmeter, scale 0–10 megohms, calibrated with 2,500 ohms in the external circuit
10—Instrument box
11—Pilot light, Mazda 47, 6.3 volts, 0.15 ampere

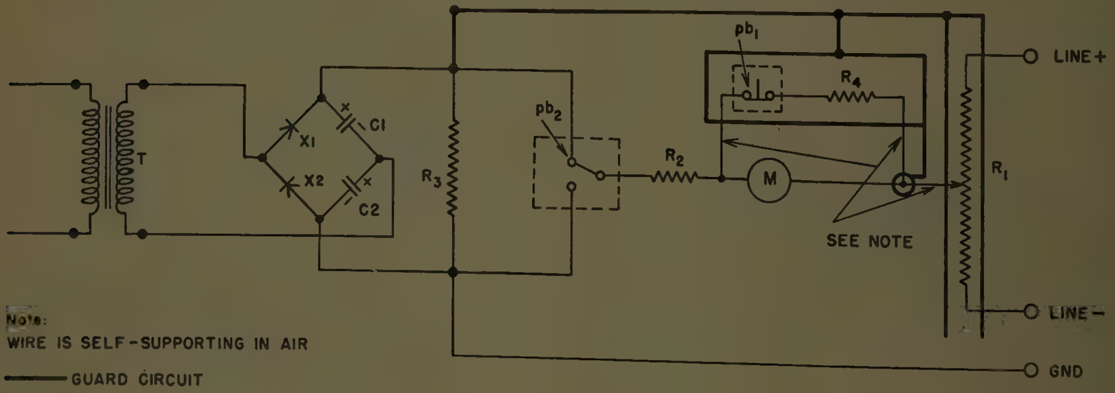
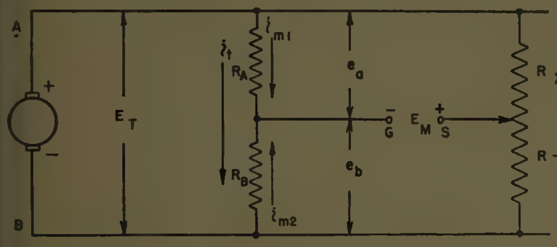


Figure 6. Schematic diagram of simplified version of the ground detector

T—115/230-volt 60-cycle transformer (constant potential type)
R_1*—Potentiometer, linear, 5,000 ohms, 100 watts*
R_2*—Resistor, 5,000 ohms, 100 watts*
R_3*—Resistor, 25,000 ohms, 10 watts*
R_4*—Shunt to the ammeter resistance*
x_1 *and* x_2*—Dry-disc rectifier, 120 milliamperes, 500 volts*
C_1 *and* C_2*—Capacitor, 100 microfarads, 600 volts*
pb_1*—Single-pole single-throw switch, push button, normally closed*
pb_2*—Single-pole double-throw switch, push button, normally closed, on ohmmeter circuit*

ter and manually controlled potentiometer. is system is illustrated in Figure 5. The ector circuit is designed to allow for observa- n of voltages as low as 0.25 volt, yet will t be damaged by voltages as high as several ndred volts. The ohmmeter, which is a tifier-powered device, is normally connected tween the compensating potentiometer and ound. By depressing switch 3, the operator n insert the detector, adjust the potentiometer the null point, and then release the switch observation of the insulation resistance as asured by the ohmmeter.

In another version of this principle, as shown Figure 6, a d-c milliammeter, with scale ibrated for resistance, performs the dual ction of ohmmeter and null detector. How- r, the resultant advantage of simplicity and er components is offset by the increase in insulation ess resulting from this circuit. This point is further rified in a subsequent section of this article. Further- re, such a scheme would require provisions for a constant ential at the output of the rectifier for any load current hin the capabilities of the milliammeter. However, ause of the possibility of zero- or low-resistance grounds ting, means must be provided for protecting the circuit inst excessive currents. This circuit has been simplified her by eliminating the error-compensating potentiom- , employed in the circuit of Figure 5, by using a smaller (5,000 ohms) bal- ing potentiometer. This would intro- e a maximum possible error of 1,250 hs, but by proper calibration of the liammeter it can be reduced to ±625 hs. This potentiometer would necessi- the dissipation of approximately 100 ts for a 700-volt system as compared 50 watts' dissipation of the corre- nding potentiometer in the unit of ure 5. If it is desired to record nges in insulation resistance, the ncing operation can be made auto- ic, servoactuated by the unbalance age. The automatic ground detector ld then provide a continuous record he system insulation resistance with f interruptions only during balancing.



ure 7. **Leakage currents due to components of ground detector and system voltages**

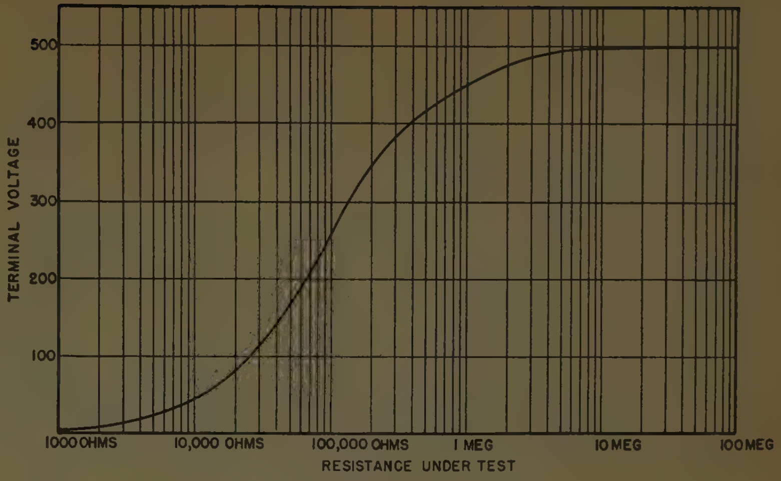


Figure 8. Voltage regulation at terminals of ground detector

GUARD SYSTEM

It is important that the use of this type of instrument should not influence the value of insulation resistance of the system. Thus, all leakage currents which may develop in the instrument due to dirt or moisture must by-pass the measuring circuit. This is accomplished by isolating or suspending in air all instrument wiring which is at a potential above ground, thus eliminating the possibility of leakage paths to ground. In the case of a component or wire which cannot be suspended thus, the leakage currents to ground are intercepted by a metallic plate or shield and conducted to the guard terminal of the ohmmeter. The guard system of the ohmmeter bypasses these currents around the instrument's current coil. The guard systems are illustrated in Figures 5 and 6 for the two described ground detectors.

SYSTEM STRESS

The employment of a ground detector on an energized circuit will alter the normal line-to-ground stress of system owing to the injected voltage of the ohmmeter. Referring to Figure 7, it will be noted that the magnitude of the insulation leakage currents to ground, normally i_t

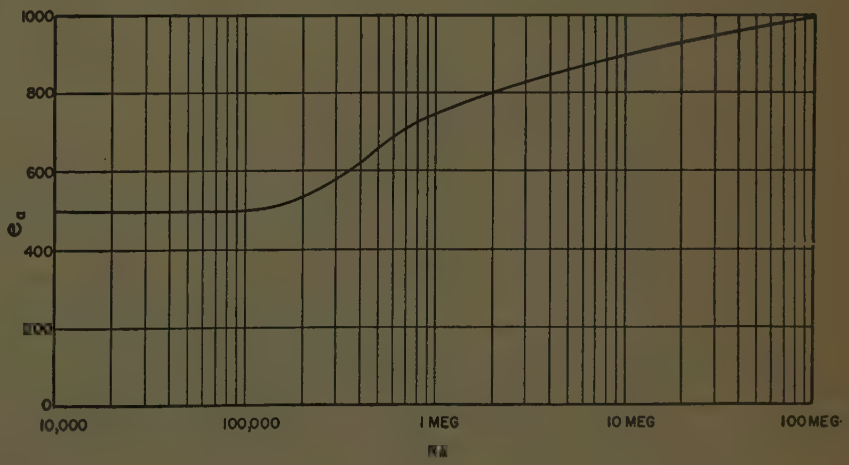


Figure 9. Possible maximum insulation stress on system, due to components of ground detector and system voltages

for each line, has been modified by currents i_{m1} and i_{m2} induced by the ohmmeter voltage E_M. From inspection it may be observed that the effect of the ohmmeter currents is to raise the voltage of the line A to ground and decrease correspondingly the voltage of line B.

In a normal system the line stresses are

$$e_a = \frac{R_A}{R_A+R_B} E_T \tag{5}$$

$$e_b = \frac{R_B}{R_A+R_B} E_T \tag{6}$$

When a ground detector is connected to a system and properly balanced so that

$$\frac{R_A}{R_B} = \frac{R_x}{R-R_x} \tag{7}$$

the corresponding stresses of equations 5 and 6 become

$$e_a = \frac{R_A}{R_A+R_B} E_T + \frac{R_A+R_B}{R+R_A+R_B} E_M \tag{8}$$

$$e_b = \frac{R_B}{R_A+R_B} E_T - \frac{R_A+R_B}{R+R_A+R_B} E_M \tag{9}$$

Owing to the fact that the value of R is very small for magnitudes of R_A and R_B greater than one megohm, these relations may be simplified as follows:

$$e_a = \frac{R_A}{R_A+R_B} E_T + E_M \tag{10}$$

$$e_b = \frac{R_B}{R_A+R_B} E_T - E_M \tag{11}$$

where

E_T = system voltage
E_M = ohmmeter voltage of the ground detector
e_a = voltage from Line A to ground
e_b = voltage from ground to Line B
R_A = insulation resistance to ground of Line A
R_B = insulation resistance to ground of Line B
R = total resistance of balancing potentiometer (10,000 ohms in the subject instruments)
R_x = potentiometer resistance from slider to line at balance

Consideration of equations 10 and 11 reveals that as the insulation resistance of Line B is reduced to zero, the voltage to ground of Line A approaches in magnitude the sum of the system plus ohmmeter voltages. If the ohmmeter's driving voltage is equal to the system voltage, the insulation stress of Line B will approach twice system voltage. This stress could result in breakdown of the insulation. However, this has been averted in the developed ground detector by employing a power supply with voltage regulation characteristics shown in Figure 8. Thus a decrease in voltage accompanies a decrease in resistance below one megohm; this results in the driving voltage adaptin itself to the condition of the insulation. The maximu voltage that can be experienced by a 500-volt system unde any condition may be observed in Figure 9. It is to b noted that for the higher values of insulation resistance th system stress can go above 500 volts. However, a consideration of the values of insulation resistance and th required ratios of the resistance for each line to groun reveals that it is highly improbable for the system t experience voltages from 750 to 1,000 volts. Furthermor when these conditions are established the insulation resistance is sufficiently high to withstand the stress.

The ground detector of Figure 6 requires a power suppl with no voltage regulation if the calibration of the ohmmeter is to be independent of internal leakage curren through the guard circuit. However, if the power suppl is designed with sufficient voltage regulation to avoi overstressing of insulation at low values of resistance, will result in inaccuracies when measuring in the range o approximately 0.1 megohm and above. This inaccurac is attributed to guard circuit currents affecting the voltag at the terminals of the ohmmeter.

RESULTS AND CONCLUSIONS

THE INSTRUMENT has been developed with a measurin range of 5,000 ohms to 10 megohms and a stressin voltage of 500 volts. During operation it has been foun that null circuit can be balanced with 0.25 volt. Th magnitude of unbalance has no discernible influence o the observed reading, and hence the accuracy of the un is as high as that of the ohmmeter employed.

The instrument has been employed successfully durin the major part of the year to measure insulation resistanc over a wide range of system voltages on direct as well a alternating currents. Periodic calibration has indicate that the instrument retains its accuracy and that the performance is stable and thoroughly reliable.

This instrument can be employed to measure accuratel the insulation resistance of any ungrounded d-c or a- system whether energized or nonenergized. It contain its own source of electromotive force for stressing th insulation to its rated voltage but with such regulation a to render the stress proportional to the condition of th insulation. The unit is direct reading and simple t operate.

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2. The Physical Nature of the Electric Breakdown of Solid Dielectrics, Karl Wi Wagner AIEE *Transactions*, volume 41, 1922, pages 288–98.

1950 Year Book Issued

The 1950 edition of the AIEE Year Book has been issued, in accordance with 1949–50 budget provisions. Addresses are corrected as of July 1, 1950. Copies have been distributed to all national, District, and Section officers, Student Branch counselors, and all members of national committees. Fellows, Members, and Associates may obtain copies by writing to AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. The Year Book is not available to nonmembers of AIEE; nor is its use permitted for commercial, promotional, or circularization purposes.

Totally Enclosed Auxiliary Drive Motors for Generating Stations

J. G. NOEST
MEMBER AIEE

BECAUSE OF certain developments in the design of equipment for central stations and because of changes in the general economic conditions, the performance d reliability of essential auxiliary drive motors has come increasingly important. A reassessment of the quirements for such motors and a discussion of their onomic justification therefore appears to be in order.

The major developments which have occurred over the t 10 to 15 years are as follows:

1. Boiler and turbine inlet steam pressures and tempera- es have risen steadily. As ever higher steam pressures re applied, the unit principle of design gained the upper nd on economic grounds. With the unit principle of nt design, a greater premium has been thrust on im- oved reliability of the main components of the plant, such boilers, turbogenerators, and the essential auxiliaries. th the unit principle of design, duplication of equipment the form of operating reserve for the major, essential xiliaries is either held to a minimum or avoided ogether, thus further accentuating the need for their eater reliability.

2. Toward the end of World War II and for several rs thereafter, electrical lity systems have had to erate with a minimum spare capacity. The ex- iences gained through such eration and the develop- nt of statistical methods the evaluation of spare acity requirements are ing confidence in the eration of systems with a nimum of spare capacity.

In the past seven years the Consolidated Edison Company of New York, Inc., has purchased 580 totally enclosed fan-cooled motors with an aggregate rating of 52,000 horsepower for major auxiliary application in new plant installation. It has been possible to justify the higher cost of totally enclosed motors on the basis of reduced maintenance and greater reliability.

other factor in these considerations is the present high t of new plant installation.

Because of the lowered amount of spare or reserve acity available today, it is natural that this spare acity should lie in units of the oldest, least economical es. Therefore, the incremental heat rate incurred h the outage of a modern unit is high and reflects in an portant manner on the cost assignable to auxiliary ipment when such equipment is the cause of the age. Together, these factors put further emphasis on reliability of station auxiliary equipment.

3. Labor wage rates have more than doubled in the ten years without a significant increase in productivity. is, in turn, means that the cost of maintenance and air has increased similarly. This condition puts a h premium on that kind of equipment which requires only a minimum number of operating and maintenance personnel.

When, after the last war, the Consolidated Edison Company of New York faced the necessity of major generating capacity expansion, the design features of the auxiliary drive motors were carefully studied in view of these general considerations and in view of accumulated operating experience.

EXPERIENCE

WITH increasing fuel costs, the development of highest temperature and corresponding highest pressure steam-generating equipment received new impetus. The development of such equipment in the largest possible capacities has not proceeded without the customary growing pains. The tightening up of spare or reserve capacity has resulted in higher loading of equipment for longer periods of time. Both of these factors have operated to disclose increased hazards.

Case 1. At one of the major stations, early one morning in December 1943 with the outside temperature below freezing and with a strong northwest wind blowing, a load swing of undetermined origin occurred, causing the safety valves of all boilers in operation at the time to blow off for several minutes. This strong wind caused the steam, escaping from the safety valves, to be driven back into the upper portions of the boiler room where the forced and induced draft fans are located, condensing on the relatively cold surfaces of the building and on the windings and frames of motors. The operators, being handicapped by the dense fog, could do nothing to shut off electric equipment in the affected areas. As a result of the condensation, two 200-horsepower 3-phase 2,300-volt commutator motors driving induced draft fans failed in their stator windings; four rotor circuit transformers used on these commutator motors flashed over internally (these are dry type); and one 3-speed 1,200/600/200-horsepower squirrel-cage induction motor flashed over in its stator windings. The station suffered a capacity loss of 100 megawatts for

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Full text of paper 50-226, "Totally Enclosed Auxiliary Drive Motors for Generating Stations," recommended by the AIEE Committees on Power Generation and Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23-27, 1950. Not scheduled for publication in AIEE *Transactions*.

J. G. Noest is with the Consolidated Edison Company of New York, Inc., New York, N. Y.

several days. The motors involved in these failures were open-frame dripproof types.

Case 2. Another major station has eight boilers with an equivalent capacity of 506 megawatts, operating at 1,200 pounds per square inch gauge and 900 degrees Fahrenheit. This installation was made between 1938 and 1941, and it was at that time a pioneering venture. Since 1944 this station has experienced three boiler tube failures where the steam escaped into the boiler room. Each of these cases resulted in the loss of one of the major auxiliary drive motors, such as forced- or induced-draft fan motor. Because this station is designed on the unit principle and without duplication of the auxiliary equipment, the auxiliaries for each boiler are supplied from a single 2,300-volt load feeder, so that the failure of any one motor on this feeder trips it out, de-energizing all the remaining equipment on the same feeder. It is believed that this feature was responsible for holding the loss down to a single motor in each case. On one of these occasions insulation resistance measurements were made on all of the motors in the exposed area within a half-hour after the boiler tube failure. These showed in each case that the insulation resistance had dropped to less than 10,000 ohms. At that time four 600-horsepower forced- and induced-draft fan motors and two 1,500-horsepower boiler feed pump motors were involved. All of these were open-frame dripproof types. In two of the cases of boiler tube trouble the associated motor failures occurred on the auxiliaries of the same boiler. In the third case, the escaping steam caused the forced-draft fan motor of an adjacent boiler to fail, resulting in the outage of two boilers. This is a serious situation in a unit type of plant, where one of the basic assumptions justifying that particular design is that the failure on one unit will not cascade to another.

Case 3. At a third station, which is an integrated type of plant, each main generating unit is supplied from four boilers, all of which are tied to a common steam header. For the two 160,000-kw units the 16 induced-draft fans, driven by 3-speed 1,000/450/150-horsepower motors, are located in a common roof monitor above the main roof of the boiler house. Immediately below the grating floor of this roof monitor are two 24-inch 400-pounds-per-square-inch-gauge-pressure main steam headers, one on each side.

In December 1945, a feed-water regulator failed, allowing one boiler to fill completely and overflow into one of the main steam headers. The sudden chilling of this steam line caused a flange gasket to blow out, leaving a 1/8-inch-by-8-inch opening discharging superheated steam into this area. Because of the time of the year, most of the windows were closed so that the escaping steam was largely confined within the room. Again, because of the dense fog, the operators were handicapped in their attempt to shut down equipment. Within minutes, 9 of the 16 1,000-horsepower induced-draft fan motors flashed over in one or both of their windings. The failure of these motors resulted in a loss of 300 megawatts of station capacity, and although it was possible to restore 200 megawatts the same day by operating five of the motors on the undamaged windings, all nine had to be rewound eventually. Her again, the motors were open-frame dripproof type.

Case 4. When, in the beginning of 1943, the station i case 3 had to be loaded to its full capacity because c increasing area loads and because of the addition of th load of an aluminum reduction plant, a series of windin failures developed in six of the motors that were involved i case 3. These failures were caused by erosion of the winding insulation through a sand-blasting effect of cinde contaminated air.

The excessive amount of cinders came from a large number of otherwise insignificant leaks in the fan housings an duct work of the induced-draft fans. Because of hig loads on these boilers, the flue gas pressures at the base c the smoke stack, in the duct work, and in the fan housing rose above atmospheric pressure causing the excessiv discharge of cinders. It took several months to locat and repair these leaks, but in the meantime the six moto failures could not be avoided. As stated in case 3, thes motors were open-frame dripproof type.

Case 5. Through a study made over a 5-year perio from 1936 to 1941 inclusive, on the causes of failures c motors of 50 horsepower and larger in size, it was disclose that out of 188 failures 35, or 18.6 per cent, were caused b water from broken pipes, fittings, leaking gaskets, leakin stuffing boxes on pumps, and so forth, entering the motor All of the motors involved were open-frame drippro design.

Case 6. At the station of case 1, there are four boile which are equipped with mill and mill blower motors c totally enclosed fan-cooled design. These motors ar located almost directly under the boilers. All four c these boilers are of the slag-bottom type which means tha in operation, the floor of the boiler combustion chambe is a pool of liquid slag with a temperature in excess c 2,000 degrees Fahrenheit.

On at least six occasions the molten slag has broke through the chrome ore bottom of the boilers, spilling ove motors and mills. Whenever this happens, the operato attempt to stop the flow of molten slag by chilling the are of the leak with streams from fire hoses. In this proces the motors are often drenched with salt water. Althoug there are 32 motors in the area subjected to these conditions, there has been only one motor failure and tha occurred when the specific motor was completely submerged in the molten slag. At least nine of these moto would have failed because of hot slag and salt wate drenching if they were not the totally enclosed type.

MAINTENANCE

In all of the stations of the Consolidated Edison syster motor maintenance is carried out on the basis c schedules, subject to modification and revision as operatin practices vary. These schedules take into account th divergent degrees of exposure hazards and they are c ordinated with the schedules for outages of related majc equipment, such as boilers or turbogenerator sets. Tw types of maintenance operations are involved: (1) inspe tion and cleaning, and (2) overhaul.

An inspection and cleaning operation on open-frame motors consists of an inspection of windings, bearings, quirrel-cage bars, short-circuiting rings, rotor fans, and o forth, as far as these items are visible without dismantling f the motor. The cleaning consists of blowing out of the windings and frame pockets with compressed air at moderte pressure.

An overhaul consists of dismantling the motor by removing the bearing brackets and withdrawing the rotor. The windings are carefully inspected for looseness in the lots or at the winding supporting rings. Any worn spots n the windings are repaired and loose winding support ording is replaced. Generally the windings are given a oat of insulating varnish after they have been thoroughly leaned. The bearings are checked and rebabbitted or eplaced, as required. The bearing brackets are cleaned nd the bearing housings are washed out to remove all ccumulated sludge. The squirrel-cage bars and connections to the short-circuiting rings are inspected for racks or broken welds. Shaft seal drains and labyrinths re inspected and cleaned. Insulation resistance and dielectric tests are made.

The frequency and per-unit costs of maintenance for open-frame dripproof motors and for totally enclosed motors have been obtained from three of the major generatng stations of the Consolidated Edison Company. The requency of maintenance work is shown in Table I.

Table I. Maintenance Periods for Open-Frame Motors

	Inspection	Overhaul
Forced-draft fan motors	1 month	2–4 years
nduced-draft fan motors	1 month	1–4 years
Boiler feed pump motors	1–3 months	2–5 years
Mill motors	1–2 months	1–2 years
Typical pump motors	1–3 months	1–4 years
Miscellaneous auxiliary motors	1–3 months	1–5 years

On totally enclosed motors inspections are not made. Although the experience with totally enclosed motors is limited, it appears that routine overhauls may be dispensed with. The maintenance work on this type of motor s expected to consist of infrequent repairs as may be equired, occasional air gap measurements to determine bearing wear, and lubrication. This is borne out by the ollowing experiences.

The earliest installation of a totally enclosed motor, onsisting of a group of 16 mill and mill blower motors of 50-horsepower and 75-horsepower rating, respectively, was made in 1929. These motors are equipped with antifriction bearings and experience has shown that the bearing ife is 15,000 to 20,000 hours. Therefore, these motors re dismantled every two years for the installation of new bearings. Except for one failure, previously mentioned, his scheduled replacement of bearings has been the only eason for overhauling the motors to date.

Another group of totally enclosed mill and mill blower motors of 100-horsepower rating was installed in 1946. This is the same group of motors discussed in case 6. In his group there has been only one failure, caused by a lamping finger of the rotor core laminations breaking off nd cutting into the stator winding. This occurred in 1947, after approximately one year of operation. Because of that failure, the other 15 motors were disassembled to permit placing additional spot welds on the clamping fingers. No other maintenance work was done at that time. Since then no maintenance work, except lubrication, has been done nor is any contemplated in the near future. These motors have sleeve bearings.

Backed by the experience on these two groups of totally enclosed motors it is expected that no maintenance work, other than lubrication, will be needed. Although a considerable number of totally enclosed motors have been installed within the last two years, the experience with these, while entirely satisfactory to date, is evidently of too short duration to permit reaching a definite conclusion.

Since a considerable factor in the justification of totally enclosed motors lies in the expected maintenance savings, careful attention must be given to design and factory workmanship so that the anticipated savings can actually be realized.

ENCLOSURE TYPES

With the background of experience related in cases 1 to 6 and combined with the further knowledge that moisture proofing by means of varnishes (except perhaps silicone varnishes) will not protect windings against condensing steam or water, particularly after some years of operation, there arises the question as to what type of enclosure will eliminate these types of failures.

In attempting to answer this question consideration might be given to these enclosure types:

1. Splashproof.
2. Enclosed pipe-ventilated or base-ventilated.
3. Totally enclosed fan-cooled, water-cooled, or pipe-ventilated.

The splashproof enclosure, although it would effectively eliminate the hazard of dripping or splashing water, will not solve the steam condensation or excessive dirt problem. The enclosed pipe-ventilated or base-ventilated motor, when supplied with clean air free from snow or fine rain, should eliminate not only the hazard of dripping or splashing water but the hazard of steam and dirt as well. The difficulty is, however, that the procurement of clean air free from snow or fine rain requires the use of filters and, in most cases, long ducts which, in turn, necessitate the installation of separate motor-driven blowers, thus adding to installation and maintenance costs.

The totally enclosed motor alone seems to meet all of the requirements with respect to protection against all of the hazards previously discussed. On the Consolidated Edison system, the fan-cooled form has been the only one purchased to date. In a number of cases economic studies have been made comparing the over-all costs of fan-cooled, water-cooled, and pipe-ventilated enclosures, and even though ambient temperatures were as high as 55 degrees centigrade, requiring winding insulation of class *B* or *H*, the fan-cooled enclosure has proved most economical. This is the case also for water-cooled motors which, because of restrictions in the use of city water for cooling purposes, require the installation of additional heat exchangers to

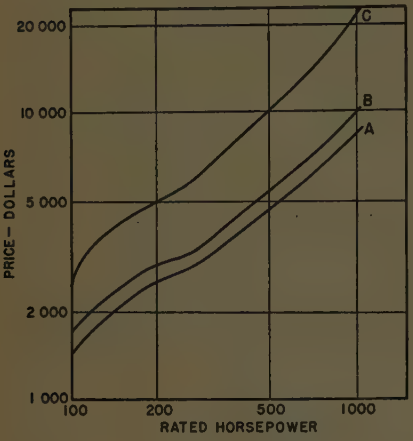


Figure 1. Price versus horsepower rating for 1,200-rpm class-A insulated motors. (A). Open-frame dripproof motors, 40-degree - centigrade rise. (B). Splashproof motors, 50-degree - centigrade rise. (C). Totally enclosed fan-cooled motors, 55-degree centigrade rise

salt water, with additional pumps and oversize equipment (the salt water temperature reaches 85 degrees Fahrenheit in the summer). For pipe-ventilation schemes the location of the motors usually dictates long and complex duct systems to insure a continuous supply of sufficiently low-temperature air. Invariably the cost of such duct work exceeded the increment in motor costs for class-*B* or -*H* insulation at 55 or 75 degrees centigrade rise, respectively.

Table II. Standard Limits of Observable Temperature Rise of Machine Windings

	Temperature by Thermometer, Degrees Centigrade	Temperature by Resistance, Degrees Centigrade
General Purpose Motors		
Insulation class *A*	40	50
Insulation class *B*	—	—
Totally Enclosed Motors		
Insulation class *A*	55	60
Insulation class *B*	75	80
Other Types of Motors		
Insulation class *A*	50	60
Insulation class *B*	70	80

Table III. Limits of Observable Temperature Rise of Machine Windings

Insulation	Temperature by Thermometer, Degrees Centigrade	Temperature by Resistance, Degrees Centigrade
Class *B*	55	60
Class *H*	75	80

INSULATION CLASS AND TEMPERATURE RISE

INDUSTRY STANDARDS[1] give permissible limits of observable temperature rise for motors which are shown in part in Table II.

The National Electrical Manufacturers Association Standards[2] recognize a service factor of 1.15 for 3-horsepower and larger motors of the general-purpose type with class-*A* insulation and 40-degree centigrade temperature rise rating. Although the standards are not explicit in this respect, it is generally understood that such motors, when carrying continuously the load permitted by service factor, will have a temperature rise not exceedi 55 degrees centigrade by thermometer.

Considering that, when motors are not exposed to unusu hazards, the experience with general-purpose motors, rat and applied in accordance with the cited standard,[2] vast and generally satisfactory, it can safely be stated th these standards, in so far as they apply to general-purpo motors, were wisely chosen. It appears important th that a service factor be available as a safety factor, ignorance factor, for totally-enclosed motors to allow f divergencies in ambient temperature and in loadin Thus, even with an ambient temperature 15 degrees cen grade in excess of 40 degrees centigrade, or a load per cent in excess of nominal rating, the motor still w operate within the limits permissible for its insulation a therefore will have an acceptable life.

In the application of motors to power plant auxilia drives, it is rarely possible to predict accurately the ambie temperature or to be certain that it will not exceed degrees centigrade, particularly for forced-draft fa induced-draft fans, mills, and other boiler auxiliari In addition, it frequently is found that the loads impos on motors may exceed the anticipated load because contingency operating conditions or because of variatio in operating procedure. It is very desirable, therefo that such a service factor, which is available only general-purpose motors with 40-degree centigrade r ratings, be obtainable in some way on motors with mo complete enclosures. Such a service factor, safety fact or ignorance factor, as the case may be, becomes availab when totally enclosed motors are purchased with class- or class-*H* insulation and with temperature rises as sho in Table III.

If a service factor of 1.15 is allowed on the basis of t temperature rises in Table III, the respective recogniz limits for class-*B* or class-*H* insulation will not be exceede

COSTS

FIGURE 1 shows the relation between the prices a ratings of open-frame dripproof motors, splashpr motors, and totally enclosed fan-cooled motors. The are based on the prices of standard-temperature-rise mot having class-*A* insulation and were prepared from catalog base prices and catalogue listed modification prices whi were in effect on May 1, 1950.

The reason for basing the curves on 1,200-rpm class insulation motors only is to illustrate the effect on prices the different enclosures and frame sizes without regard other features.

The increase in price for class-*B* insulation for a 55-degr centigrade rise ranges from approximately 7.5 to 25 per ce above the base price for class-*A* insulation and depends the motor horsepower rating and speed with the larg value corresponding to the lower speed. For class insulation, 75-degree centigrade rise motors, there generally a 10-per cent increase in price over the class 55-degree centigrade rise motors, although in the larg sizes equal prices occasionally are quoted.

A considerable number of economic studies have sho t the increased cost of totally enclosed motors is justifiable to approximately 250 horsepower on the basis of main- ance savings alone. An outage of a motor up to this rsepower rating seldom involves the loss of a main unit, d therefore no considerable additional credit can be igned on the basis of increased reliability.

For motors above 250 horsepower the difference in price ween open-frame dripproof and totally enclosed motors reases at a greater rate than the evaluated difference in intenance costs. However, an outage of a motor rated) horsepower and above generally involves a main it, and the higher cost of the totally enclosed motor is tifiable on the basis of increased reliability in addition the savings in maintenance costs. The loss of capacity tor and the incremental heat rate cost may outweigh all er factors for the larger auxiliary drive motors as for culating water pumps, forced- and induced-draft fans, d boiler feed pumps.

Whether or not the purchase of totally enclosed motors n be justified depends on the type of design of the plant and on the degree of reliability which is expected. The adoption of the unit type of plant design, the extent to which duplication of auxiliaries is provided, and the amount of reserve capacity available to the system obviously will influence the decision.

On the Consolidated Edison system it generally has been found that for essential auxiliaries in power plants totally enclosed motors can be economically justified. On this basis a total of 580 totally enclosed motors with an aggregate rating of 52,000 horsepower has been bought since 1943.

It appears reasonable to expect that a thorough investigation of all of the factors entering into the design of auxiliary power drives and their comparative evaluation will disclose that totally enclosed motors may be economically justifiable to a greater extent than in the past.

REFERENCES

1. Rotating Electrical Machinery. *Standard C-50*, American Standards Association, New York, N. Y., 1943.

2. Standards for Motors and Generators. *Publication MG-1-4.15*, National Electrical Manufacturers Association, New York, N. Y., 1949.

Electrical Essays

Motionally Induced Electric Fields—Part IV

Motional Electromotive Force in Iron, Commutatorless D-C Motor, and Space Ship

ack, the physicist, is continuing his lectures to Alter Ego d his friends on the basic principles underlying dynamo- ctric machines.

ack: "We now have the universal equation for the mo- al electric field, $\mathbf{E}_{mot}$, induced in any honest-to-goodness dy moving with a velocity **v** in a magnetic field **B**, mely

$$_{t}=\frac{1}{c}[\mathbf{v}\ \mathrm{x}\ \mathbf{B}] \qquad (1)$$

is universal equation is consistent with the principle of ergy, for if **i** is the current density in the body, we will ve

$$=\mathbf{E}_{mot}\cdot\mathbf{i}=[\mathbf{v}\ \mathrm{x}\ \mathbf{B}]\cdot\mathbf{i}=\mathbf{v}\cdot[\mathbf{B}\ \mathrm{x}\ \mathbf{i}] \qquad (2)$$

$=c\mathbf{E}_{mot}\cdot\mathbf{i}$ is the electric power supplied per unit volume the moving body external circuit.

'We find the mechanical power by means of the uni- sal equation

$$=[\mathbf{i}\ \mathrm{x}\ \mathbf{B}]=-[\mathbf{B}\ \mathrm{x}\ \mathbf{i}] \qquad (3)$$

ich gives the mechanical force, per unit volume $\mathbf{F}_m$, ich the magnetic field **B** exerts upon any body carrying current density **i**. The mechanical power, per unit volume, which the moving body delivers to other bodies is then

$$P_m=\mathbf{v}\cdot\mathbf{F}_m=-\mathbf{v}\cdot[\mathbf{B}\ \mathrm{x}\ \mathbf{i}] \qquad (4)$$

"Combining equations 2 and 4 we have

$$P_e+P_m=0 \qquad (5)$$

That is, if the moving body is delivering electric power, as in a generator, then equal mechanical power must be supplied to it, and if the body is receiving electric power by **i** flowing against $\mathbf{E}_{mot}$, as in a motor, then it will deliver an equal mechanical power. Universal equations 1 and 3 are entirely in order as far as the principle of energy is concerned.

"But now, Alter Ego has something to say."

Alter Ego: "I am very glad to learn of the universal validity of equations 1 and 3 because based on them I have made two very important inventions; namely, a commutatorless d-c motor or generator, and a d-c driven space ship. I won't go into the details of these inventions, but will limit myself to describing their basic principles.

"Go back to the slide-wire experiment, Figure 1, and consider what will happen if the slide bar is a cylinder of very high permeability iron. The lines of force of the otherwise uniform magnetic field **B** will converge as is shown in Figure 2, and **B**, within the circular section iron bar, will have almost twice the strength which it would have in a similarly placed copper bar. Therefore, according to your universal equation 1 which you say is absolutely right, the motional field $\mathbf{E}_{mot}$ in the iron bar will be twice what you would get for a copper bar.

"Now for my invention. Make a coil like I show in Figure 3, with two parallel sides, but make one of these

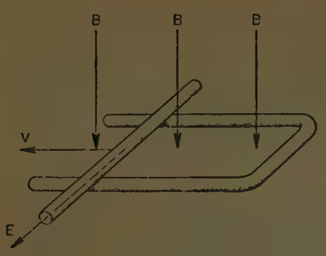


Figure 1 (above). The slide-wire experiment

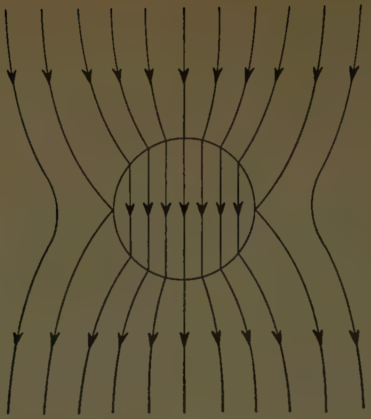


Figure 2 (right). Converging field in iron cylinder

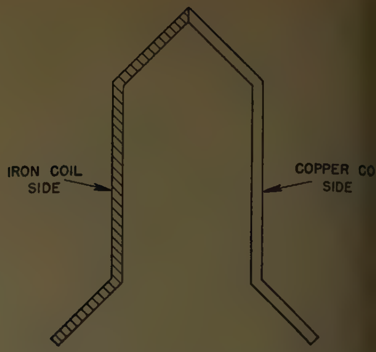


Figure 3. Iron-copper coil

parallel sides of iron and the other of copper. Now translate the coil in the magnetic field. There will be motional fields induced in the coil sides. If the coil had been all copper, then the motional field $\mathbf{E}_{\text{mot}}$ in the one coil side would oppose and just cancel the motional field $\mathbf{E}_{\text{mot}}$ in the other coil side, so far as the production of a total electromotive force around the coil is concerned. However, with one coil side iron, the motional field $\mathbf{E}_{\text{mot}}$ in it will be twice the motional field in the other side, copper coil, and these motional fields will not cancel round the coil, but the coil will give a net, not zero, electromotive force as it is moved in the uniform magnetic field. It is easy to see how we could mount a lot of these coils in series on a rotating member with slip rings, in a uniform magnetic field, and get a beautiful constant d-c voltage. There's your commutatorless d-c generator.

"Now, consider what happens if I send current through my (patent-pending) iron-copper coil while it is in a uniform magnetic field. If the coil had been all copper, then, according to your universal and absolutely right equation 3, the forces exerted by the magnetic field on the coil sides would be equal and opposite and would exactly cancel. However, in my iron-copper coil, the field $\mathbf{B}$ in the iron side is twice what it is in the copper side, and therefore, according to your universal equation 3, the force on the iron side will be twice the oppositely directed force on the copper side, and I will get a net force tending to move the whole coil. If I arrange a lot of these coils around on a rotor as in my generator, I'll get a commutatorless d-c motor. However, if I lay the coils out in a plane, I'll get a space ship, since the reaction on the field-producing member will be the same as if the coils were all copper, namely, zero. Aren't those wonderful inventions, Dr. Jack?"

Jack: "I don't like to throw cold water on your enthusiasm, Alter Ego, but I doubt that your inventions will work. You will remember that in my last lecture (*EE, Jan '51, pp 67–68*), I showed that the sum of all the electric fields, the electrostatic, that induced by transformer action, and the motional, when integrated round any closed material circuit, was equal to $1/c$ times the rate of change of the integral of $\mathbf{B}$ over any surface enclosed by the circuit, or in other words, to $1/c$ times the rate of change of the total flux linked by the circuit. Now, as your coil moves in the uniform magnetic field, the amount of flux linked by it does not change. Therefore, the total current-producing electromotive force which is around your coil stays zer

"Of course, you should have obtained the same resul
using the motional equation 1, but you did not. Som
people think that the $\mathbf{v}$ in equation 1 stands for the motio
of the moving body, not relative to space or some suitabl
material frame of reference but relative to the magneti
field itself, and that where the field lines bunch up as i
your iron bar the bar carries them along somewhat, so tha
the lines of force slide or cut through the bar with onl
half that velocity with which they are cut by the coppe
bar so that the motional field is the same in the iron as th
copper. Maybe that is the way out. . . ."

I interrupt Jack at this point, because I am already b
hind in my reply to the preceding essay and I must catch u

Will Jack be able to explain away the contradictio
along the line he has indicated? Watch for the ne
exciting episode in the next installment.

J. SLEPIAN (F '2
(Westinghouse Research Laboratories, East Pittsburgh, P

Three Impedances

Three impedances are so proportioned that whe
connected in star and energized from a 60-cycle syste

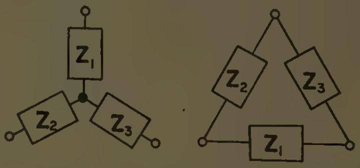


Figure 1. Star and del
connections of thr
impedances

they form a network that is equivalent to a network forme
by the same three impedances connected in delta. Is th
possible?

A. A. KRONEBERG (F '
(Southern California Edison Company, Los Angeles, Cal

Answers to Previous Essays

Correction to Motionally Induced Electromotive Force. T
following is the author's correction to the Part II essay a
the answer to Part I (*EE, Dec '50, pp 1086–9*).

The units used in these essays on "Motionally Induc ectromotive Force" are Gaussian, that is, **E**, **D**, **P**, ρ, and are in centimeter-gram-second electrostatic units, and **B**, **M**, and **i** are in centimeter-gram-second electro- agnetic units. Other quantities such as **v**, c, **F**, and so rth, are in centimeter-gram-second units. With these its, **v** and c occur in all equations as the ratio $\mathbf{v}/c$. It emed to the author that this relationship of **v** to c is orth emphasizing, and with these units the continual ap- arance of $\mathbf{v}/c$ gives this emphasis.

However, the author slipped from consistent adherence these units in a few places in *Electrical Engineering*, De- mber 1950. On page 1086, the lines following equation should read, "where cVI is the electrical power input, I^2 is the Joulean heat developed, and $cV_0I=vIBl$ is the echanical power, since IB is the force . . ."

On page 1089, column 1, line 17 from the bottom, the uation should read

$$\left(\mathbf{i}+\frac{1}{4\pi c}\frac{\partial \mathbf{D}}{\partial t}\right)=\text{curl }\mathbf{H}$$

tead of as given.

J. SLEPIAN (F'27)

(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Motionally Induced Electromotive Force—Part III. The lowing is the author's answer to his previously published ay (*EE, Jan '51, pp 67–68*).

No, there is no motional field $\mathbf{E}_{\text{mot}}$ in vacuum or, for that tter, anywhere else, in the author's opinion. Having osen a particular frame of reference in which Newtonian rticle mechanics holds, or better yet, relativistic particle chanics holds, then we may define **E** and **H** from the ces which we observe on small enough charged material obes placed at that point in empty space where we wish observe **E** and **H**. Then Maxwell's equations are nd to hold for these vectors **E** and **H** thus defined in pty space. Within matter **E** and **H** are as yet un- ined, since the operation of observing forces on a rged probe to be placed within matter has no meaning. However, **E** and **H** are observable in empty crevices in tter, and if we assume that Maxwell's equations hold **E** and **H** so observed in any and all the crevices which can construct in the material body, then it follows that ations 1, 2, 3, and 4 given on page 1088 (*EE, Dec* define vectors **E**, **D**, **H**, and **B**, which we call the electro- gnetic field vectors for the material body.

The velocity **v** which enters into the definition of these d vectors is the velocity of the material of the body which nds the crevice. If now we *define* the charge density y the equation $4\pi\rho=\text{div }\mathbf{D}$, and the current density **i** the equation $4\pi\left(\mathbf{i}+\frac{1}{4\pi c}\frac{\partial \mathbf{D}}{\partial t}\right)=\text{curl }\mathbf{H}$, then Maxwell's d equations will hold for all these quantities, thus ned ultimately by means of measurements of force on rged probes at rest or moving in empty space, and in e particular frame of reference.

ncluding ρ and **i**, we have then five vector field quan- s and one scalar field quantity which enter in Maxwell's d equations. These last are two vector equations ch refer to curl **E** and curl **H**, and two scalar equations which refer to div **D** and div **B**. Maxwell's field equations are then not mathematically determinate, since they have more dependent variables than the number of independent equations.

To make a mathematically determinate system, we postulate that sufficient additional relations are imposed upon the field quantities by the material itself. These constitutive relations are dependent upon the nature of the material, and may be expected to vary with the pressure, temperature, and so forth, of the matter, possibly also with its past history, and, important for our present purpose, also with its velocity. These constitutive relations may be found by experiment, or may be deduced from theories of the microscopic structure of matter, and of the behavior of microscopic particles, electrons, dipoles, nuclei, and so forth. They are the data of Maxwell theory and not any part of the conclusions from Maxwell theory.

Maxwell's field equations are equivalent to six independent scalar equations, and the field quantities are equivalent to 15 independent scalar variables. To make a mathematically determinate system, the constitutive relations must then be equivalent to nine independent scalar relations.*

Thus for empty space we have $\mathbf{D}=\mathbf{E}$, $\mathbf{B}=\mathbf{H}$, $\mathbf{i}=0$, and $\rho=0$, which are equivalent to nine independent scalar equations. Again, for a nonmagnetic metal at rest we may have $\mathbf{i}=\sigma\mathbf{E}$, $\mathbf{B}=\mathbf{H}$, $\mathbf{D}=0$, $\rho=0$, again equivalent to nine independent scalar equations.*

The problem of the electromagnetism of moving bodies is thus reduced to the problem of determining what are the constitutive equations for the matter of bodies in motion. Is there some general method whereby from a knowledge of the constitutive relations for the material making up a body at rest, we may deduce the constitutive equations for that body in uniform motion with velocity **v**?

Minkowski and Einstein described such a general method in 1905. Given a body at rest, for which constitutive equations connecting the field quantities **E′**, **D′**, **H′**, **B′**, **i′**, and ρ' are known. Then if in these equations we substitute

$$\mathbf{E}'=\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]$$

$$\mathbf{D}'=\mathbf{D}+\frac{1}{c}[\mathbf{v}\times\mathbf{H}]$$

$$\mathbf{H}'=\mathbf{H}-\frac{1}{c}[\mathbf{v}\times\mathbf{D}]$$

$$\mathbf{B}'=\mathbf{B}-\frac{1}{c}[\mathbf{v}\times\mathbf{E}]$$

$$\mathbf{i}'=\mathbf{i}-\frac{1}{c}\rho\mathbf{v}$$

$$\rho'=\rho+\frac{1}{c}\mathbf{v}\cdot\mathbf{i} \qquad (1)$$

---

* Any vector equation may be written as the three equations between the component of the two sides of the equation. However, the three components of the curl of any vector **A** must not be regarded as independent since we have always the scalar equation div curl $\mathbf{A}=0$. Therefore, the equation of Maxwell referring to curl **E** must be regarded as equivalent to only two independent scalar relations, and similarly for the equation concerning curl **H**. Also, the field quantities **i** and ρ must always satisfy the equation div $\mathbf{i}+\frac{\partial\rho}{\partial t}=0$. Therefore, **i** and ρ must be regarded as equivalent to only three independent scalar quantities.

we will get the constitutive equations for that body moving with uniform velocity **v**.[**]

Let us apply this method to determine the constitutive equations for the moving glass rod of Alter Ego. For the rod at rest, we have

$$\begin{aligned}&\mathbf{D}'=\epsilon\mathbf{E}'\\&\mathbf{B}'=\mathbf{H}'\\&\mathbf{i}'=0\end{aligned}\qquad(2)$$

Substituting equation 1 we have the desired constitutive equations

$$\begin{aligned}&\mathbf{D}+\frac{1}{c}[\mathbf{v}\times\mathbf{H}]=\epsilon\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right)\\&\mathbf{B}-\frac{1}{c}[\mathbf{v}\times\mathbf{E}]=\mathbf{H}-\frac{1}{c}[\mathbf{v}\times\mathbf{D}]\\&\mathbf{i}-\frac{1}{c}\mathbf{v}\rho=0\end{aligned}\qquad(3)$$

If we neglect higher powers of v/c than the first, then equation 3 reduces to

$$\begin{aligned}&\mathbf{D}=\epsilon\mathbf{E}+(\epsilon-1)\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\\&\mathbf{B}=\mathbf{H}-\frac{\epsilon-1}{\epsilon}\frac{1}{c}[\mathbf{v}\times\mathbf{D}]\\&\mathbf{i}=\frac{1}{c}\mathbf{v}\rho\end{aligned}\qquad(4)$$

Thus we see that Jack's guess at the constitutive equation of the glass rod, his equation 10 (*EE, Jan '51, p 68*), is wrong. Jack's motional field, $\mathbf{E}_{\text{mot}}=1/c[\mathbf{v}\times\mathbf{B}]$ does not produce induction **D** like "any other field $\mathbf{E}_s$." Also we see from the second of equations 4 what Jack appears not to even suspect, namely that the glass rod which is nonmagnetic at rest will become magnetic, that is, **B** will not equal **H** for it, if it moves in an electric field **D**.

The air in Alter Ego's inner tube will also have the constitutive equations 4, but as it is pumped out, ϵ will approach 1, and the constitutive equations will approach those for a vacuum, with **v** disappearing. There is then no motional electric field in a vacuum (or anywhere else for that matter).

Now that we have the constitutive equations for a glass rod, we may readily solve the problem of what will be the field in a glass rod moving in an otherwise uniform magnetic field. We shall do that in the reply to the next essay which will deal with a somewhat similar problem.

J. SLEPIAN (F '27)

(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Reactive Power. The following is the author's answer to his previously published essay (*EE, Jan '51, p 68*).

The reactive power for the general case of an alternating current and an alternating potential difference where both have harmonics is the algebraic sum of the reactive powers corresponding to the sinusoidal harmonic components

$$Q=E_1I_1\sin\theta_1+E_3I_3\sin\theta_3$$

For the networks submitted in the essay

$$\theta_3=-\theta_1;\quad Z=\sqrt{R^2+X^2}$$

and the reactive power may be written

$$Q=\pm\frac{E_1^2-E_3^2}{Z}\sqrt{1-\Lambda^2}$$

from which the per-unit expression for reactive power

$$Q'=\pm\frac{E_1^2-E_3^2}{E_1^2+E_3^2}\sqrt{1-\Lambda^2}$$

Computing rms voltages and currents in the elements the network, the following is found to be the per-unit reactive power in the series network A

$$Q'_A=1.25\frac{E_C^2-E_L^2}{E_C^2+E_L^2}\sqrt{1-\Lambda^2}$$

Similarly, for the network with a parallel connection reactive elements B, the per-unit reactive power is

$$Q'_B=1.25\frac{I_C^2-I_L^2}{I_C^2+I_L^2}\sqrt{1-\Lambda^2}$$

The correct sign of reactive power is given by the equations. It is possible to conceive a circuit of zero powe factor and of zero reactive factor. In such a circuit th apparent power is entirely fictitious and is equal to th distortion power. This occurs when $R=0$, and $E_3=E_1$.

A. A. KRONEBERG (F'4

(Southern California Edison Company, Los Angeles, Cali

Star or Delta? The following is the author's answer t his previously published essay (*EE, Jan '51, p 68*).

Impedances comprising both networks can be expresse in Heaviside operational form

$$Z_a=Lp;\quad Z_b=Z_c=R\qquad(1$$

$$Z_B=Z_C=R+2Lp;\quad Z_A=2R+1/Cp=2R+R^2/Lp\qquad(2$$

Using these values of impedances in equations for tran formation from star to delta or vice versa, it can be demo strated that the two networks are equivalent. Whe networks are equivalent when expressed in Heavisi operational form, they are networks of "general equi alence" as defined in American Standard Definitions Electrical Terms:[1] "If one network can replace anoth network in any system whatsoever without altering in a way the electrical operation of that portion of the syste external to the networks, the networks are said to be ne works of 'general equivalence.'" When such networ are enclosed in similar containers and only their termina are available for testing, it is impossible to determine purely electrical measurements the nature of the netwo in each container.[2–3]

REFERENCES

1. American Standard Definitions of Electrical Terms. *AIEE*, Section 65.20.6 1941, page 215.

2. Which Box Contains the Network? J. Slepian. *Electrical Engineering*, volume December, 1948, page 1141.

3. Network, A. A. Kroneberg. *Electrical Engineering*, volume 68, November, 19 page 984.

A. A. KRONEBERG (F'

(Southern California Edison Company, Los Angeles, Ca

[**] Equations 1 are not precisely the transformation equations of relativity theory as given by Einstein and Minkowski but differ by terms involving the second and higher powers of v/c.

NSTITUTE ACTIVITIES

ve Sessions Held at Conference on Electron Tubes for Computers

ıat a better exchange of ideas should
between manufacturers of vacuum
s and the designers of computer circuits
one of the main conclusions reached at
Conference on Electron Tubes for
puters. The conference was sponsored
he AIEE and Institute of Radio Engi-
s, in collaboration with the Panel on
tron Tubes of the Research and De-
pment Board, at Haddon Hall Hotel,
ntic City, N. J., December 11–13, 1950,
was attended by more than 300 engineers
all parts of the country and from as
way as Canada and England. A great
of the credit for the success of the con-
ce is due to Dr. C. V. L. Smith, head of
Computer Section, Office of Naval
arch.

he need for this conference arose from
results of a survey conducted by Dr.
. Samuel, chairman of the Panel on
tron Tubes of the Research and De-
pment Board of the Department of
nse, who noted indications that the
of electron tubes for computers was in
of clarification. The general chairman
e conference committee was Dr. Mina
, Office of Naval Research, who, in
pening address to the first session of the
rence of which she was chairman,
ned the nature of the five sessions and
would be covered by the 31 papers
nted. In addition to the exchange of
between tube manufacturers and users,
stated that the demand for tube re-
ity is paramount because "down time"
to tubes in computers is more or less
rable when the cost of such installa-
and their operating costs are so high.

. R. Clark, Leeds and Northrup Com-
, opened the first session, which was on
puter experience with electron tubes.
eviewed the AIEE tube conference held
iladelphia in 1948 and the one in 1949
uffalo, N. Y., at which tube manu-
rers and their customers exchanged
that resulted in general improvements
oth. The tube manufacturers were
d in their programs and they explained
t the tubes which were marketed for
mentation. The speaker also pre-
d statistics concerning the tube con-
tion of 1950 over that of the previous
which in several instances showed an
ase of more than 100 per cent.

e next paper, "Experience with Re-
g-Type Vacuum Tubes on the Whirl-
Computer Project," was given by E.
ich, Massachusetts Institute of Tech-
y (MIT). He outlined the tests em-
d at MIT for various tube defects and
esults obtained: many specific tubes
omputers show a better performance
commercially available tubes, but the
can be made to function satisfactorily
cautions are taken to avoid the use of
its which demand performance beyond
ubes' capabilities.

J. A. Goetz and E. W. Brooke, International Business Machines Corporation, presented "Electron Tube Experience in IBM," which was read by the former. The 1,000-hour tests showed that low plate current was the chief cause of failure in high-voltage tubes and this same cause together with cathode defects were troublesome in miniature tubes. Other types of failures were intermittent short circuits, heater defects, faulty cutoff, grid emission, and mechanical defects. Life-expectancy and survival curves developed from test data were found to be more or less conclusive.

"Performance of Electron Tubes in the ENIAC," by W. E. Erion and H. W. Spence, Aberdeen Proving Ground, and presented by Mr. Erion, was the last paper of the session. This paper covered the findings of a 9-month test on tubes used in ENIAC, those tubes which are normally off and normally on. It was found that by giving an 8-hour "overhaul" at the beginning of each week to the computer, there are comparatively few tube failures in the remaining 112 hours of weekly operation. Checking of 10 types of tubes showed that they had a useful life from 6,000 to 12,000 hours, and the authors gave the reasons for the different tubes' failures; short-circuited elements, open filaments, and low emission were the principle causes of failure.

The afternoon session was devoted to electron tube problems and S. N. Alexander of the National Bureau of Standards presided over the meeting. J. O. McNally, Bell Telephone Laboratories, opened the session with "Design and Operation of Tubes for Long Life," in which were given the results of tests on 1,000 tubes on their cathode temperature for different heater voltages. One of the conclusions reached was that tubes should be run with slightly less than their rated voltages on the elements in order to give longer life. From a test of approximately 1,600 tubes, it was shown that there was no great advantage in removing tubes after a certain number of hours of active life; the percentage of tubes surviving plotted against time follows rather closely an exponential curve.

The next speaker, J. R. Steen, Sylvania Electric Products, Inc., discussed "The JETEC Approach to the Tube Reliability Problem." The Joint Electron Tube Engineering Council (JETEC) investigates various engineering problems and gives its findings to the parent association of which the National Electrical Manufacturers Association and the Radio Television Manufacturers Association are members. Mr. Steen defined reliability of tubes, which covers many different phases of use. The JETEC ratings take into consideration the application to which a tube is put. It was brought out that in order to obtain greater reliability in tubes, there should be closer co-operation between the tube manufacturer and the users—that more information should be exchanged.

1951 Summer General Meeting Committee

The General Committee for the 1951 AIEE Summer General Meeting is shown preparing plans for this important meeting to be held at the Royal York Hotel, Toronto, Ontario, Canada, June 25 to 29, 1951. Committee chairman, O. W. Titus, estimates that about 1,800 will be registered for this meeting. Above, left to right, seated: J. T. Fisher, Bell Telephone Company of Canada, 76 Adelaide Street, West, Toronto, Secretary; W. R. Harmer, Hydro-Electric Power Commission (HEPC) of Ontario, Vice-Chairman; O. W. Titus, Canada Wire and Cable Company, Chairman; A. H. Frampton, English Electric Company of Canada, Ltd., Vice-President District 10; D. F. Martin, Packard Electric Company, Ltd.; J. H. Smith, Canadian General Electric Company. Standing, left to right: M. C. Thurling, Canadian General Electric Company, Treasurer; G. A. Brace, Ferranti Electric Ltd.; M. J. McHenry, HEPC of Ontario; J. T. Thwaites, Canadian Westinghouse Company; J. Y. Doran, Toronto Transportation Commission (representing, at the time of the picture, committee member J. G. Inglis); Marino Fraresso, HEPC of Ontario; D. G. Geiger, Bell Telephone Company of Canada (member-at-large); E. M. Haacke, Electrical News and Engineering; P. J. Croft, Canada Wire and Cable Company. Missing from the photograph is W. J. Gilson, a member-at-large

Future AIEE Meetings

Southern District Meeting (*page 165*)
Macfadden-Deauville Hotel, Miami Beach, Fla.
April 11–13, 1951
(*Final date for submitting papers—closed*)

North Eastern District Meeting
Hotel Syracuse, Syracuse, N. Y.
May 2–4, 1951
(*Final date for submitting papers—February 1*)

Great Lakes District Meeting
Loraine Hotel, Madison, Wis.
May 17–19, 1951
(*Final date for submitting papers—February 16*)

Summer General Meeting (*page 163*)
Royal York Hotel, Toronto, Ontario, Canada
June 25–29, 1951
(*Final date for submitting papers—March 27*)

Pacific General Meeing
Multnomah Hotel, Portland, Oreg.
August 20–23, 1951
(*Final date for submitting papers—May 21*)

Fall General Meeting
Hotel Cleveland, Cleveland, Ohio
October 22–26, 1951
(*Final date for submitting papers—June 22*)

"Cathode Interface Impedance and Its Effects in Aged Vacuum Tubes" was the subject of H. B. Frost, Massachusetts Institute of Technology. The oxide coating on the nickel core of the cathode has an interface which is equivalent to a parallel resistance-capacitance circuit, which acts like a semiconductor and it is unwanted for a long tube life. An accelerated life test has been devised and results seem to indicate that the interface depends on the metal of which the cathode is made, that is, the nickel and the amount of silicon in it.

L. S. Nergaard, Radio Corporation of America Laboratories, carried the discussion of the cathode interface further in his paper, "Cathode Impedance and Tube Failure." He brought out that the rate of growth of the interface is an important factor as well as the duty cycle; the lower the duty, the higher the growth of interface resistance.

The last paper of the afternoon, "6SN7WGT and 6AN5; Mutual Conductance Dispersion and the Effect of Low Duty Cycle Operation on Long Life Performance" was given by I. Levy, Raytheon Manufacturing Company. The two tubes mentioned in the title of the paper are "ruggedized" and, in the course of tests for computer use, were subjected to shock tests. It was found that the transconductance dispersion was an important factor; the longer the life, the greater this dispersion, but a lot of 25 tubes showed that the majority of them would be acceptable. The author also discussed the make-up of the cathode interface layer and its influence on tube performance. He explained about normal and passive alloy cathodes and it was thought that the latter was preferable.

An open discussion on "Improved Electron Tubes for Computers" was the final event of the session in which the following subjects were considered: the possibilities of an accelerated life test; the use of a shock-testing machine and its effect on an accelerated test; noises in tubes; and a reciprocal educational exchange between computer circuit designers and tube manufacturers.

A. L. Samuel, International Business Machines Corporation, was the chairman of the evening session on special purpose computer tubes. The first paper, "A Stable Binary Electrostatic Storage System," was given by A. M. Clogston, Bell Telephone Laboratories, who explained the functioning of the storage tube. The next speaker, J. Rajchman, Radio Corporation of America, described how another type of tube functioned in his paper, "Recent Experiences with the Selective Electrostatic Memory Tube," and how the tube operated and its improvements. "The MIT Storage Tube" was the subject of P. Youtz, Massachusetts Institute of Technology. This beam-deflection storage tube, which was described in *Electrical Engineering*, November 1950, page 990, was tested in a pilot tester and run 8 hours daily for a month. The speaker described the tests and the theory underlying the tube, stating that even as yet some phases of its operation are not clearly understood; for example, some of the spot interaction.

T. Van Dyk, Rogers Majestic Electronics, Ltd., of Canada, described "The Development of the Rogers Additron," which is an electrostatically focussed radial double-beam tube primarily for use as a binary adder tube in high-speed digital computers. The internal construction of the tube consists of 12 control elements placed symmetrically and circularly around the cathode and connected to form three electrodes. Twelve collector elements are placed on a circle and opposite the gaps between the control elements. Alternate collector elements are connected internally to form two collector electrodes and these are shielded from each other by a screen. If one of the eight possible combinations of a zero voltage and a positive voltage is applied to the three control electrodes, the electrostatic field set up in conjunction with the self-bias of the tube directs the electron beams to either a sum or a carry collector element, to neither, or to both.

"A Proposal for a Binary Adder Tube Utilizing Beam Deflection Principles" was presented by D. H. Gridley, Naval Research Laboratory. In this tube the circular beam is replaced with one of a "ribbon" cross section formed by an electron lens. This may be a double-beam tube with six anodes or targets, two sets of deflection plates, and four inputs, but these can be used in single form.

The last three papers of the session dealt with counting tubes, the first of these being "Special Cold Cathode Discharge Tube for Counting and Switching Applications" by M. W. Wallace and J. Heney, Federal Telecommunications Laboratories, and presented by the former; the second paper, "A Decimal Counting Tube," was given by T. R. Kohler, Phillips Laboratories; and the final one by F. J. Cooke, Remington Rand Corporation, was on "New Improvements and Applications in Remtron Counter Tubes." The first of these papers described several types of gas-filled tubes, which in general are slower than vacuum tubes. Mr. Kohler described a Dutch decade counter in which a ribbon-shaped beam is focussed on a slotted screen in which are
openings of different widths, this ele
beam being used as a counter. The
tron tube, described in the last paper
session, is described as being economica
will function at 100 kc.

The morning session of December 1
devoted to tube manufacture and c
diode experience and J. G. Brainerd,
versity of Pennsylvania, was the chai
The first paper, "Design and Manufact
Electron Tubes for Electronic Com
Service," was presented by R. E. Higg
H. E. Stuman, Radio Corporatio
America, and read by the former.
design requirements of computer
were discussed and by using the
current equation it was shown how the
current depends directly on the cathode
and inversely as the square of the gr
cathode spacing. The on-off servic
tubes causes a relatively short life due
cathode interface and the silicon in
cathode sleeve that causes the tro
Another troublesome factor is any mo
of the control grid, which should be sp
with lampblack to prevent secon
emission, as the grid is often driven pos
Various other factors in tube manufa
were discussed: experienced operator
assembly; careful control of parts; ren
of all foreign matter from interior of

The second paper, "Problems in
Manufacture of Special Tubes for Com
Use," was by R. L. McCormack, Rayt
Manufacturing Company, and read by
Rockwood. After discussing reasons
tube failure—either poor manufactur
poor use on the part of the circuit design
he told about manufacturing objects and
quality is influenced by processing
testing. Methods of life tests were expla
80 per cent of tubes tested must pass, so
four out of five tubes will work satisfact

R. W. Slinkman, Sylvania Electric
ucts, Inc., presented "Development o
7AK7." This gate tube was devel
two years ago especially for binary comp
with a fast pulse rate and was put
production in four months, about one
the usual allowable time. The econo
aspects of putting a new tube into produ
were outlined and a comparison
between tubes for television receivers
those for computers.

"Application of Germanium Diod
Computers" was given by N. DeV
General Electric Company, in which
described the manufacturing diffic
encountered and the tests made. Os
grams were shown illustrating good and
up-drift, down-drift back currents.

"SEAC Experience with Germa
Diodes," written by J. H. Wright an
J. Slutz, both of the National Burea
Standards, was presented by Mr. W
A description was given on how the swit
in SEAC was performed by the 1
germanium diodes and how they are us
flip-flop circuits. In approximately
hours of use there was 0.4 per cent fa
during computer breakdown.

H. B. Frost, Massachusetts Institu
Technology, presented his second pap
the conference, "Crystal Diode Life
perience in the Whirlwind Com
Circuits." He told about the 9,500 d
in the Whirlwind computer and how i
found that diodes used in flip-flop ci
have about one-half the life of those
ployed in other circuits.

H. Bigelow of the Institute for Advanced
y presided over the final session of the
rence devoted to the Williams type
ge. H. D. Huskey of the National
au of Standards opened the session with
e Experience in the SWAC." In this
ment information is stored on 37
de-ray tubes with which the Bureau
had approximately 1,500 hours' ex-
nce. This information is stored as 256
, which are regenerated once every 4
seconds. Double this number of spots
been tried, but here there is a chance
the electron beam might discharge
cent spots. An average cathode-ray
has three or four flaws on its screen so
storage cannot be effected without
al care.

EAC Storage Tube Memory System"
William Davis, National Bureau of
dards, contained a description of the
ams tube technique, which was pro-
d by Williams in 1947 and the first one
at the University of Manchester,
and. SEAC is capable of storing one
y digit unit every 48 microseconds and
tests which it has undergone thus far
been successful.

H. Pomerene, Institute for Advanced
y, described the testing of the 40
ams tubes employed in the Institute's
ment, where 1,024 spots can be put
Bad flaws are detected in cathode-ray
by Lissajous figures generated by two
ators slightly out of phase.

pparatus for Selection of Cathode-ray
s for a Williams Storage" by David
man, National Bureau of Standards,
ined data concerning the tests for
shes on the tubes' screens; the line-of-
test and the circuit used; and the
ical spot diameter test. Tubes used in
C are tested during use and indications
iven as to the location of any blemish
n what tube it occurs.

e last three papers covered the under-
theory of the functioning of the Williams
e tube; these were presented by J.
, University of Toronto; A. Holt,
nal Bureau of Standards; and L.
uin, International Business Machines
ration. The differences of opinions
sed by these authors evoked a most
d discussion.

Expected to Attend Southern strict Meeting in Miami Beach

se who attend the AIEE Southern
ct Meeting at Miami Beach, Fla.,
11–13, 1951, will find themselves
red in some of the city's finest and most
ous hotels in the North Beach section.
ng headquarters will be at the Mac-
-Deauville Hotel on Collins Avenue.
ear of the hotel faces the Atlantic
with one of the finest sections of
g beach. The beach is flanked by an
of cabanas, each equipped with
e dressing rooms, showers, furniture,
lothes closets. Between the cabanas
e hotel is a swimming pool of Olympic
tions, with 14 feet of water at its
t point. The pool slopes to shallower
which, at the ends, can accommodate
children.

adequacy of the beach and swimming
is typical of the accommodations

Sunswept pool and cabanas of the Macfadden-Deauville Hotel are only a small part of the many attractions at AIEE Southern District Meeting headquarters

awaiting the members of the Institute. The Macfadden-Deauville Hotel is too small to house the 500 persons expected to attend, so nearby hotels will also be used. The students, for example, will stay at the Northshore Hotel. This is a beautiful hotel with its own pool and dock facilities. It is near the headquarters hotel and is located on an island in Biscayne Bay. Other members will stay at the Sherry Frontenac and the Monte Carlo hotels, which lie along the oceanfront immediately south of the Macfadden-Deauville.

In the North Beach section are numerous attractive hotels, homes, and apartment buildings. There are two distinct shopping areas, each boasting a wide variety of stores. A bank, beauty salons, a wide selection of eating places, public oceanfront bathing beaches, and a movie house are in the immediate vicinity.

Members attending will do well to bring along their summer clothing. April temperature in Miami Beach averages 73.9 degrees, an ideal temperature for swimming, sunbathing, fishing, boating, golf, tennis, sightseeing, and the many other activities available here.

The members of the Southern District Meeting Committee are: Harvey F. Pierce, *General Chairman;* C. K. Lingo, *Publicity and Attendance;* Ollie T. Ayers, Jr., *Hotels and Registration;* Dr. H. H. Sheldon, *Technical Papers;* J. W. Lacy, Jr., *Program;* E. F. Johnson, *Finance;* J. W. Bevelle, *Transportation and Inspection Trips;* and C. W. Cogburn, *Sports and Entertainment.*

Technical and Student Paper Prize Awards Are Announced

TECHNICAL PAPERS

J. J. Orr, Chairman of the Committee on Award of Institute Prizes, has announced the award of the Institute Paper Prizes in each of the five technical classes for papers presented during the period August 1, 1949, to July 31, 1950. Several of the division nominating committees found it difficult to choose a first and second preference from among the technical papers in their field. However, the final decisions are quite definite. The papers selected for first and second prize are as follows:

Communication Division

First Prize awarded to:
Fundamentals of the Automatic Telephone Message Accounting System, John Meszar, Bell Telephone Laboratories, Inc.

Second Prize awarded to:
A New Electronic Telegraph Regenerative Repeater, B. Ostendorf, Jr., Bell Telephone Laboratories, Inc.

General Applications Division

First Prize awarded to:
Noise Evaluation of Fluorescent Lamp Ballasts, C. P. Hayes, H. R. Gould, General Electric Company

Second Prize awarded to:
Effect of Frequency on Perception Currents, C. F. Dalziel, University of California, and T. H. Mansfield, Tracerlab, Inc.

Industry Division

First Prize awarded to:
A Frequency-Response Method for Analyzing and Synthesizing Contactor Servomechanisms, Ralph J. Kochenburger, University of Connecticut (also Alfred Noble Prize award)

Second Prize awarded to:
Prediction of Ultimate Temperature Rise from Early Heat Run Data, J. E. Ryan, General Electric Company

Power Division

First Prize awarded to:
Coordination of Fuel Cost and Transmission Loss by Use of the Network Analyzer to Determine Plant Loading Schedules, E. E. George, H. W. Page, Ebasco Services, Inc., and J. B. Ward, Purdue University

Second Prize awarded to:
Interrupting Ability of Horn-Gap Switches, F. E. Andrews, L. R. Janes, M. A. Andersson, Public Service Company of Northern Illinois

Science and Electronics Division

First Prize awarded to:
Statistical Nature and Physical Concepts of Thyratron Deionization Time, H. A. Romanowitz, University of Kentucky, and W. G. Dow, University of Michigan

Second Prize awarded to:
The Theory of the Current Transductor and Its Application in the Aluminum Industry, T. R. Specht, Westinghouse Electric Corporation, and R. N. Wagner, Aluminum Company of America

STUDENT PAPERS

The Committee on Award of Institute Prizes has announced the award of the Best Student Paper Prizes for papers presented during the period August 1, 1949, to July 31, 1950. The committee reviewed all of the papers submitted for this prize, three reviews having been secured for each Student paper. Several of the papers considered for the second prize were of such a high order that the choice was very difficult. However, the final decisions were unanimous in all cases. The papers selected for the awards and honorable mention are as follows:

Best Student Paper Prize

Prize awarded to:
Recording Styli, the Burnishing Facet, and a Process for Resharpening, Charles F. Strandberg, Duke University

Second Prize Student Paper

Prize awarded to:
A Stroboscopic Earth Inductor Compass, Samuel A. Schwartz, University of Alabama

Honorable Mention

Awarded to:
The Reproduction of Electron Tube Characteristic Curves on the Cathode-Ray Oscilloscope, H. S. Ingraham, Jr., University of Maine

AIEE Nominating Committee to Meet in New York City

The Nominating Committee of the AIEE will meet at the Hotel Statler, New York, N. Y., January 24, 1951, during the Winter General Meeting to nominate candidates for AIEE offices to be voted on by the membership in the spring of 1951. Members of the committee are as follows:

Representing the Board of Directors:

W. L. Everitt, University of Illinois, Urbana, Ill.

R. A. Hopkins, Westinghouse Electric Corporation, Los Angeles, Calif.

J. A. McDonald, General Electric Company, Salt Lake City, Utah

Elgin B. Robertson, Elgin B. Robertson, Inc., Dallas, Tex.

Walter J. Seeley, Duke University, Durham, N. C.

Representing the ten geographical Districts:

1. F. S. Bacon, Jr., Rockbestos Products Corporation, New Haven, Conn.
2. J. A. Dinwiddie, Westinghouse Electric Corporation, Toledo, Ohio
3. J. D. Tebo, Bell Telephone Laboratories, Inc., New York, N. Y.
4. J. H. Berry, Virginia Electric and Power Company, Norfolk, Va.
5. J. C. Woods, Commonwealth Edison Company, Chicago, Ill.
6. H. F. Gidlund, Public Service Company of Colorado, Denver, Colo.
7. J. Bruce Wiley, University of Oklahoma, Norman, Okla.
8. T. M. Blakeslee, Department of Water and Power, Los Angeles, Calif.
9. Michael D. Dufly, Pacific Power and Light Company, Portland, Oreg.
10. W. R. Harmer, Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada

Alternates for Board representatives:

Walter J. Barrett, New Jersey Bell Telephone Company, Newark, N. J.

M. D. Hooven, Public Service Electric and Gas Company, Newark, N. J.

Alternates for District representatives:

1. R. V. Shepherd, General Electric Company, Schenectady, N. Y.

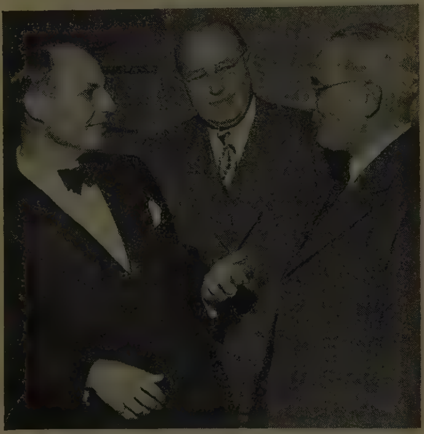
6. J. O. Kammerman, South Dakota School of Mines and Technology, Rapid City, S. Dak.

7. Marian J. Smith, Texas Technological College, Lubbock, Tex.

9. Charles B. Carpenter, Pacific Telephone and Telegraph Company, Portland, Oreg.

AIEE Lehigh Valley Section Holds Meeting at Allentown, Pa.

One hundred and fifty members of the AIEE Lehigh Valley Section attended a dinner meeting at the Masonic Temple, Allentown, Pa., on December 8, and heard Larston D. Farrar, writer and lecturer of Washington, D. C., discuss national politics. Mr. Farrar stressed the need of careful voting for candidates, and he warned the members to pay greater attention to national elections than to local ones. Illustrative of the point, he said, "is the noise made by citizens when local governments make small tax increases, and silence or unawareness on the part of the same people when Congress makes appropriations of billions of dollars." The talk was followed by an interesting question-and-answer period.



Shown at the Lehigh Valley Section meeting are, left to right, Larston D. Farrar, lecturer; Stanley C. Townsend, Allentown (Pa.) District Manager; and D. A. Campbell, Jr., Vice-Chairman of the Lehigh Valley Section

Student Branch of Newark College Meets. The Newark College of Engineering held a student branch meeting on November 14, 1950. This meeting was sponsored by the International Business Machines Corporation, and was held at their Newark office. R. A. Wadsten, technical sales representative, and C. Anderson, customer engin presented talks on Electronic Calculat and Calculators.

Over 200 Attend Third Annual AIEE Machine Tool Conferenc

Electrical engineers in the machine t industry had the opportunity to hear so excellent technical papers and take inter ing inspection trips during the 3-day c ference on machine tools. The Th Annual AIEE Special Conference on M chine Tools was held November 14, 15, a 16 at the Sheraton Hotel in Worcest Mass., and was sponsored by the Mach Tool Subcommittee of the Committee General Industry Applications, with D R. Percival as chairman. Total attendar was more than 200.

During the morning session of the f day, four papers were presented. T afternoon was devoted to plant visitati in and around Worcester, Mass. At dinner that evening, Frank J. Oliver, edi of *Electrical Manufacturing*, was the speak Six papers were given on November and there was a meeting of the Subcommit on Machine Tools. Following the aft noon meeting, approximately 150 conferer delegates left for Springfield, Vt., where final day of the conference was spent visiti four machine tool plants in the Winds Springfield area.

Assisting the Machine Tool Subco mittee in making arrangements for conference were: R. E. Pfeif, *Chairm* Worcester Section, AIEE; B. F. Hamm strom, *Chairman*, Committee in Charge Local Arrangements; G. R. Blake, G. Bibber, *Registration;* W. H. Howard, B. Hammarstrom, *Publicity;* W. G. Colem P. F. Dunigan, *Finance and Dinner;* S. I. Ri *Plant Visitation.*

Comments Are Requested on Ground-Fault Neutralizers Gui

Improvement in service is a factor power transmission and distribution wh has received considerable emphasis in rec years. One of the means of obtaining i provement in service reliability is ground-fault neutralizer. It was first plied in this country in 1921. Howev the acceptance of neutralizers as a p tective device for transmission and tribution systems has come only in rec years. Prior to 1937 only a scattered neutralizers were installed, and since t time their application has increased y by year.

Coincident with the increased interest ground-fault neutralizers, a number of pap

R. A. Wadsten a C. Anderson shown speaking Newark College Engineering s dents at a stud branch meetin

been presented and articles have ap-
l in the trade journals treating the
s aspects of neutralizers—their design,
es of certain applications, operating
, and other general information.
ver, a comprehensive guide for applica-
as not appeared in the literature.

tralizers have been installed on over-
line and underground cable systems in
ountry with voltages from 2.4 kv to
v. Their choice for application as a
tive device depends on an analysis
ing the benefits of the various protec-
hemes, and the comparative economics.
ognizing this fact, an application guide
repared to present the various criteria
may effect a proper application of a
d-fault neutralizer to a system. To
plish this purpose, the guide is divided
our sections: the ground-fault neu-
r; ratings of ground-fault neutralizers;
ation criteria; installation and opera-
riteria.

und-fault neutralizers can be installed
3-phase transmission system, whether
or network, provided certain applica-
riteria are met. In the four sections of
ide, these criteria are presented and
sed.

Guide for Application of Ground-
Neutralizers (Miscellaneous Paper
3) was presented at the Fall General
ng, Cincinnati, Ohio, October 17–21,
on a 1-year trial basis with the thought
t would be revised and put in final
at the end of the trial period. A few
are still available from the AIEE
Department. The working group
prepared this guide is anxious to
e comments and suggestions so that the
will represent current practice. These
ents should be sent to the chairman of
rking group, Mr. J. E. Clem, General
ic Company, 1 River Road, Schenec-
, N. Y., as early as possible.

bers' Views Asked on Neutral ounding Application Guide

proper way to ground the neutral or
ls of a 3-phase electric system has
a much debated subject from the be-
g of the electrical industry. Re-
e, reactance, direct-grounded, and
d neutrals have all been tried, and it
en demonstrated repeatedly in practice
orkable systems are available with any
various methods that might be used.
dingly, it should be recognized that
is no one universal answer to the
l grounding problem. However, it
sible to establish certain criteria that
esirable in the grounded systems and
the desired objectives are decided it
tively simple to select the method of
ding that best fulfills the requirements.

purpose of this grounding guide is to
ome of the basic factors to be con-
d in selecting any particular type of
ission system neutral grounding, the
f apparatus that may be used, and the
ds to be employed. It is limited to
s 23 kv and above without directly
ted generators.

Application Guide on Methods of
l Grounding on Transmission Sys-
as presented at the Fall General Meet-
Cincinnati, Ohio, October 17–21, 1949, on a 1-year trial basis with the thought that it would be revised and put in final form at the end of the trial period. It was made available on an Advance-Copy-Only basis and copies are no longer available, but the AIEE Protective Devices Committee is anxious to receive comments and suggestions from those who have copies so that the guide will represent current practice. These comments should be sent to the chairman of the working group, Mr. E. M. Hunter, General Electric Company, 1 River Road, Schenectady 5, N. Y., as early as possible.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Industry Division

Committee on Electric Welding. (*Myron Zucker, Chairman; Robert C. McMaster, Vice-Chairman; C. B. Clark, Secretary.*) Due to the success of the two former Special Technical Conferences sponsored by this committee in co-operation with the American Welding Society, it has been decided to organize another one to be held in Detroit, Mich., in April 1952. It has been suggested also that the Power Supply Subcommittee arrange a session at the 1951 Summer General Meeting in Toronto and that papers be presented by members of the Manufacturer, User, and Utility Groups.

The initial phases of the activities planned by the Fundamental Electric Arc Research Subcommittee (R. C. McMaster, Chairman) will include: (1) preparation of a bibliography on past fundamental research; (2) continuous interchange of information on research now in progress; and (3) promotion of interest and activity in fundamental arc research.

Committee on General Industry Applications. (*Kennard Pinder, Chairman; J. C. Find, Vice-Chairman; V. O. Johnson, Secretary.*) The subcommittees of this committee have devoted a large part of their time to the organization of Special Technical Conferences. Due to the broad field of electrical engineering it has become necessary for engineers to specialize in different phases of the subject. The experience of this committee has shown quite clearly that in order to bring the Institute and these specialized engineers together it is important to group them and tie them together by common interest. This results in mutual benefit to the Institute, its local Sections, and engineers attending the Conferences. An individual engineer often finds it difficult to attend a General Meeting in order to listen to one or two papers dealing with his interest. On the other hand he finds more encouragement from his management to attend a one-to-three-day Conference devoted exclusively to the electrical problems in his specific industry. All of the Special Technical Conferences to date have been arranged by a technical committee or subcommittee jointly with a local AIEE Section.

The Rubber and Plastics Industries Subcommittee is planning a fourth annual Technical Conference to be held in Atlantic City in April 1951. The Textile Industry Subcommittee is planning a Technical Conference at the Georgia Institute of Technology, Atlanta, Ga., next spring.

Committee on Mining and Metal Industry. (*T. B. Montgomery, Chairman; A. C. Muir, Vice-Chairman; L. N. Grier, Secretary.*) At a meeting of this committee held in Cleveland, Ohio, September 26, it was suggested that a new subcommittee be appointed to be called Subcommittee on Hard Rock Mining, with Mr. A. B. Chafetz named as Chairman.

The committee is planning a symposium for the Summer General Meeting to be held in Toronto. It has been suggested that this might be built around the subject of Labrador ore mining. A recommendation was also made that the committee sponsor a steel session at the Fall General Meeting in Cleveland, Ohio. The Subcommittee on Mining plans to undertake work on the revision of the American Standard for Installing and Using Electrical Equipment in Metal Mines.

Power Division

Committee on Switchgear. (*H. V. Nye, Chairman; R. L. Webb, Vice-Chairman; J. M. Geiger, Secretary.*) The Working Group on Automatic Circuit Reclosures is now working on a revision of Proposed Standard *50*, which was issued a year ago with the intention that it could be made a full-fledged AIEE Standard by next year. The Working Group on Low-Voltage Air Circuit Breakers is preparing a test code for these circuit breakers. A guide for their application is now available. The Subcommittee on Switches, Fuses, and Insulators has been requested to revise Standard *22A* to include "Maximum Design Voltage." This proposed Standard for Air Switches, Insulator Units, and Bus Supports has been out on trial use for a year.

Science and Electronics Division

Committee on Computing Devices. (*J. G. Brainerd, Chairman; W. H. MacWilliams, Jr., Vice-Chairman; and F. J. Maginniss, Secretary.*) A questionnaire has recently been sent out by Dr. MacWilliams, Jr., to a number of people interested in computing equipment preparatory to making up a bibliography of published computer literature. The proposed bibliography will be prepared jointly with the Electronic Computers Committee of the Institute of Radio Engineers (IRE). Although it is too early to set a publication date, the committee is aiming for spring or summer of this year.

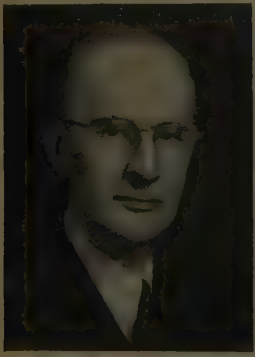
In December this committee was a joint sponsor of the Conference on Electron Tubes for Computers sponsored jointly by the AIEE and IRE in collaboration with the Panel on Electron Tubes of The Research and Development Board. Dr. J. G. Brainerd and Dr. S. N. Alexander, Chairman of Subcommittee on Digital Computers, each presided over one of the sessions at this conference. Two sessions at the Winter General Meeting in New York were devoted to computing devices papers, and plans are now under way for a session at the North Eastern District Meeting.

Electron Tubes Subcommittee of Committee on Electronics. (*H. C. Steiner, Chairman.*) One of the activities of this subcommittee during the past year was the sponsoring jointly with the Institute of Radio Engineers of a Conference on Electronic Devices. This Conference was held at the University of Michigan, Ann Arbor, Mich., on June 22 and 23, 1950, and was conducted on an informal basis, with no published papers and no minutes of the meetings, but every effort was made to encourage discussion of the latest theories and discoveries. The meeting at Ann Arbor was devoted primarily to a discussion of microwave tubes and techniques, and reports from those attending indicate that it was very successful and the exchange of ideas beneficial.

The 1951 Joint Conference will be held at the University of New Hampshire on June 21 and 22.

AIEE PERSONALITIES.....

O. B. Blackwell (A '08, M '13, F '17, Member for Life), has been awarded the 1950 Edison Medal "for his pioneer contributions to the art of telephone transmission." Mr. Blackwell, who is Assistant Vice-President (retired) of the American Telephone and Telegraph Company (AT&T), received the medal at the AIEE Winter General Meeting. He was born on August 21, 1884, in Bourne, Mass., and in 1906 he graduated from Massachusetts Institute of Technology with a bachelor of science degree in electrical engineering. That same year he began his career with the Bell System in the transmission and protection division of the AT&T Engineering Department, and in 1914 he was placed in charge of that department. When the Department of Development and Research was organized in 1919, he became transmission development engineer. In 1934, when this department was consolidated with the Bell Laboratories, Mr. Blackwell was appointed director of Transmission Development. The following year he was named manager of Staff Departments and in 1937 he became a Vice-President. Mr. Blackwell returned to AT&T in 1944 as Assistant Vice-President and also became a member of the Bell Telephone Laboratories' Board of Directors. The medalist is holder of 22 patents in the communication field. He is a member of the Acoustical Society, the American Physical Society, the American Society for the Advancement of Science, and the Institute of Radio Engineers. Mr. Blackwell has actively served the AIEE on the following committees: Telegraphy and Telephony; Meetings and Papers; Executive; Standards; Communication; Finance; Headquarters; Lamme Medal.



O. B. Blackwell

Vannevar Bush (A' 15, M '19, F '24, Honorary Member), President, Carnegie Institution of Washington, Washington, D. C., has been awarded the John Fritz Medal for "outstanding scientific contributions to his country and to his fellow men." The medal was presented to Doctor Bush at the AIEE Winter General Meeting. He was born at Everett, Mass., on March 11, 1890. He received the bachelor and master of science degrees in 1913 from Tufts College, Boston, Mass., where he became an instructor in mathematics after graduation. He was advanced to assistant professor of electrical engineering in 1916, and in the same year received doctor of engineering degrees from Massachusetts Institute of Technology (MIT) and Harvard University. Research on submarine detection with a special board on submarine devices of the United States Navy occupied him from 1917 to 1918. In 1919 Doctor Bush began a 20-year association with MIT, Cambridge, Mass., as associate professor of electric power transmission. He was named Professor in 1923 and Vice-President and Dean of Engineering nine years later. In 1939 Doctor Bush became President of the Carnegie Institution of Washington. Extremely active in the government during World War II, he was a member of the National Advisory Committee for Aeronautics and was its chairman
from 1939 to 1941. In addition, he
Chairman of the National Defense Resea
Committee, 1940–41, and was Director
the Office of Scientific Research and
velopment in 1941. Doctor Bush is kno
internationally for his development
mathematical analyzing instruments
solving complex equations in science
engineering, and is the author of m
technical books and papers. His acc
plishments have been recognized by m
than 17 educational institutions who h
granted him honorary degrees, and he
the recipient of 13 medals from engineer
and other organizations, some of wh
include: AIEE Lamme (1935) and Edi
(1943) Medals; the United States
tinguished Service Medal, 1945; the Wa
ington Award, 1946; and the Hoo
Medal, 1947. Doctor Bush is a mem
of the American Association for the
vancement of Science, the American Phys
Society, the National Academy of Scien
Tau Beta Pi, Sigma Xi, and Phi Beta Kap
Doctor Bush was a Director of the AI
from 1937–41 and has served actively
many Institute committees, some of th
being: Electrophysics; Power Transmiss
and Distribution; Education; Co-ordi
tion of Institute Activities; and Research

Vannevar Bush

K. T. Compton (F '31), Chairman of
Corporation of Massachusetts Institute
Technology (MIT), has been awarded
Hoover Medal for 1950 for "distinguis
public service." The award was presen
to Doctor Compton at the AIEE Wi
General Meeting. He was born Septem
14, 1887, in Wooster, Ohio, and recei
the degrees of bachelor of philosophy, 1
and master of science, 1909, from Woo
College and the degree of doctor of phi
ophy from Princeton University in 1
He was a member of the Wooster Coll
Wooster, Ohio, and Reed College, Portla
Oreg., faculties before becoming assis
professor of physics at Princeton Univers
Princeton, N. J., in 1915. Doctor Comp
was Chairman of the Department of Phy
at Princeton University when, in 1930,
was appointed President of MIT. He
named Chairman of the MIT Corpora
in 1948. Doctor Compton is a holde
the Washington Award for 1947, and
American Academy of Arts and Scien
Rumford Medal. He has been hon
many times with the honorary degree
doctor of science, doctor of laws, and do

K. T. Compton

engineering. He is a member of the
erican Optical Society, American Physi-
Society, Franklin Institute, American
idemy of Arts and Sciences, and the
hor of some 100 publications dealing with
trical and physcial research and de-
opments. Doctor Compton served on
AIEE Edison Medal Committee from
0–45.

J. Kochenburger (A '49), assistant pro-
or of electrical engineering, University
Connecticut, Storrs, Conn., has been
arded the Alfred Noble Prize for 1950
his paper "A Frequency-Response
thod for Analyzing and Synthesizing
ntactor Servomechanisms." The prize
s presented to him at the AIEE Winter
neral Meeting. Doctor Kochenburger
s born on November 2, 1919, in Jersey
y, N. J. He was graduated from
ssachusetts Institute of Technology in
0 with the degree of bachelor of science
electrical engineering and received his
ster of science degree from the same
itution in 1941. He was with the
tiss Propeller Division of the Curtiss
ght Corporation in Caldwell, N. J., as
arch engineer from 1941 to 1946, and
946 returned to MIT to obtain his doctor
cience degree in electrical engineering.
tor Kochenburger joined the faculty of
University of Connecticut as assistant
essor in 1950. He is a member of Sigma
and Eta Kappa Nu.

R. J. Kochenburger

C. Crittenden (A '19, M '22, F '44),
ciate director of the National Bureau of
dards, Washington, D. C., has retired.
was born on December 19, 1880, in
ayo, Pa. After graduating from Cornell
versity, Ithaca, N. Y., he remained as an
uctor in physics for four years. In 1909
began his career with the National
au of Standards as an assistant physicist
he Photometric Laboratory. In 1921
tor Crittenden became chief of the
rical division and remained in this
ion until 1933, when he was made
ant director. In this latter position he
responsible for the over-all research
ities of the Bureau, in addition to his
es as a member of many Bureau com-
ees. Doctor Crittenden is noted for his
evements in the measurement and
dardization of light. In 1946, he was
ded an honorary doctor of science
ee by the Case Institute of Technology, and the Gold Medal of the Illuminating Engineering Society. Doctor Crittenden is also a member of the American Optical Society, the Illuminating Engineering Society, the American Physical Society, American Association for the Advancement of Science, Phi Beta Kappa, and Sigma Xi. Doctor Crittenden has been an active member of the AIEE and has served on the following Institute committees: Lighting and Illumination; Production and Application of Light; Research; Technical Program; Award of Institute Prizes; and Standards.

A. M. Harrison (M '46), manager, medium machine section, D-C Generator Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed manager of the D-C Generator Engineering Department. In his new position, Mr. Harrison will be responsible for the engineering design and development of all medium- and large-sized d-c generator and motors for the company. After graduating from the Carnegie Institute of Technology in 1926, with the degree of bachelor of science in electrical engineering, Mr. Harrison became associated with Westinghouse. He has had several patents granted to him in the field of d-c machine design and has had published several papers and technical articles.

R. A. Galbraith (A '38), Head of Electrical Engineering Department, Syracuse University, Syracuse, N. Y., has been made Dean of the L. C. Smith College of Applied Science at Syracuse University. Doctor Galbraith graduated from the University of Missouri, Columbia, Mo., in 1933 with a bachelor of science degree in electrical engineering and remained as a member of the faculty for two years. He received the doctor of philosophy degree from Yale University in 1937 when he was National Graduate Fellow of Tau Beta Pi. Before going to Syracuse University, Doctor Galbraith was on the faculty at the Georgia Institute of Technology, Atlanta, Ga., and previous to that he was on the staff of the Radar School at the Massachusetts Institute of Technology, Cambridge, Mass. He is currently serving the Institute on the Student Branch Committee.

C. L. Frederick ('46), Owner and Manager, Carl L. Frederick and Associates, Chevy Chase, Md., has been awarded the degree of Doctor of Science by Nebraska Wesleyan University. Mr. Frederick was graduated from Nebraska Wesleyan University in 1925 with a Bachelor of Arts degree in physics and mathematics. In 1927 he received the Master of Arts degree in physics from George Washington University. Mr. Frederick's professional experience is broad in scope. Before entering business for himself he was contractor to the United States Air Force on evaluation of electronic test equipment. He also has been consultant to the Research and Development Board and to the Weapons Systems Evaluation Group, both under the Office of the Secretary of Defense. Mr. Frederick is a member of the American Physical Society, Institute of Radio Engineers, Institute of Aeronautical Engineers, American Chemical Society, and Sigma Pi Sigma.

E. H. Schulz (A'37, M'43, F'50), Chairman, Electrical Engineering Department, Armour Research Foundation, Chicago, Ill., has been named acting chairman of physics research. Dr. Schulz received his Bachelor of Science degree in 1935 and his Master of Science degree in 1936, both in electrical engineering, from the University of Texas. He was awarded his Doctor's degree in 1947 from the Illinois Institute of Technology, Chicago, Ill., while engaged as an instructor in electrical engineering. He became Chairman of the Electrical Engineering Department in 1947, a post he will retain in addition to his new duties. Dr. Schulz is a member of the Institute of Radio Engineers and the American Society for Engineering Education.

E. E. Grazda (A '42), assistant editor, *Electrical Equipment*, Sutton Publishing Company, New York, N. Y., has been named editor of the publication. Mr. Grazda was former associate editor of *Electrical Engineering*. He was graduated from New York University in 1942 with a Bachelor of Science degree in electrical engineering. He became assistant editor of *Electronics*, New York, N. Y., from 1941–42, and in 1943 he joined the Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., as a field engineer. Mr. Grazda has served from 1948–50 on the joint AIEE-IRE Conferences on Electronic Instrumentation in Nucleonics and Medicine. He is a member of the Institute of Radio Engineers and Eta Kappa Nu.

C. W. Higbee (M '37), manager, Electrical Wire and Cable Department, United States Rubber Company, New York, N. Y., has been elected President of the National Electrical Manufacturers Association. Mr. Higbee attended Rensselaer Polytechnic Institute, and after serving in the Engineer Corps as a First Lieutenant during World War I he entered the employ of the United States Rubber Company in 1919. He has been associated with that company continuously, holding the positions of technical superintendent, general sales manager, and manager, his present post.

A. H. Lauder (A '24, M '43, F '49), assistant manager, Large Motor and Generator Divisions, General Electric Company, Schenectady, N. Y., has been appointed manager of engineering for the divisions. Mr. Lauder was graduated from the University of Wyoming in 1922 and came to General Electric that year as a student engineer in the company's Test Course. He joined the Large Motor and Generators Divisions in 1923 and remained until 1945, when he was appointed to the staff of the manager of General Electric's Schenectady Works. He rejoined the Large Motor and Generator Divisions in 1947, and was named assistant manager a year later.

A. L. Davis (M '46), Engineer, Service Engineering Division, General Electric Company, Schenectady, N. Y., has been appointed manager of service of the Transportation Divisions of General Electric's Apparatus Department. The position will be one of evaluating and analyzing service requirements for the transportation industry. Mr. Davis' previous experience includes association with the Los Angeles (Calif.) Street Railway Company where he was superintendent of car maintenance.

E. E. Cobb (A '31, M '48), Electrical Project Engineer, Ebasco Services, Inc., New York, N. Y., has joined the staff of Westcott and Mapes, Consulting Engineers of New Haven, Conn., as Senior Electrical Engineer. Mr. Cobb received his Bachelor of Science degree in 1929 from Oklahoma Agricultural and Mechanical College.

OBITUARY • • • •

Walter Gordon Clark (A '03, F '24, Member for Life), Consulting Engineer, Clark and Son, Inc., Los Angeles, Calif., died December 17, 1950. Mr. Clark was born in Salt Lake City, Utah, on October 23, 1876, and attended the Van Dernalen School of Engineering and the University of California. In 1897 Mr. Clark became superintendent of the Western Electric Light and Power Company of San Francisco, Calif., and in 1900 he helped organize the Kilbourne-Clark Company in Seattle, Wash. Four years later he became engineer and manager of the Ansonia Brass and Copper Company, Ansonia, Conn. From that time on he served in the capacity of consulting engineer. Mr. Clark directed mining developments and hydraulic power installations in the Yukon territory. He also served as consulting engineer in India and as chairman of the board of engineers of the Victoria Falls and Transvaal Power Company in South Africa. Mr. Clark was also a member of the American Society of Civil Engineers, the American Association for the Advancement of Science, and the American Institute of Mining and Metallurgical Engineers.

Frank Thurman Leilich (A '09, M '25). Consulting Engineer, Baltimore, Md., died November 19, 1950. Mr. Leilich was born on July 13, 1888, in Baltimore, Md., and received the degree of electrical engineer in 1908 from the Baltimore Polytechnic Institute. In 1909 he was granted the master of science degree from Lehigh University and the next year became an instructor in electrical engineering at the University of Pittsburgh (Pa.). Mr. Leilich served in the United States Engineer Corps during the first World War. In 1919 he became associated with Consolidated Gas Electric Light and Power Company of Baltimore, Md. In 1941 Mr. Leilich re-entered the military service and served as a Colonel in the United States Army until 1948 when he was honorably discharged. Mr. Leilich served the Institute on the following committees: Power Generation 1926–30, General Power Applications 1935–38.

Birney Clark Batcheller (M '17, Member for Life), retired, died November 27, 1950. He was born in 1865 and was graduated from the Massachusetts Institute of Technology in 1886 with a bachelor of science degree in mechanical engineering. Mr. Batcheller was noted for his work in the pneumatic postal tube system. He designed and directed the construction of the underground pneumatic postal tube systems in Boston, New York, Philadelphia, Chicago, and St. Louis.

Carl Adien Wolfrom (A '10, Member for Life), Palos Verdes Estates, Calif., died on August 3, 1950. Mr. Wolfrom was born on December 22, 1881, in Bellevue, Ohio, and attended the University of Michigan. In 1902 he entered the service of the Utah Power and Light Company.

MEMBERSHIP • • •

Recommended for Transfer

The board of examiners at its meeting of December 21, 1950, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Adams, F. C., prof. of elec. engg., Worcester Polytechnic Institute, Worcester, Mass.
Bullard, W. R., elec. engr., Ebasco Services, Inc., New York, N. Y.
Calabrese, G., prof. of elec. engg., New York University, New York, N. Y.
Corfield, R. J., elec. engr., Kennecott Copper Corp., Garfield, Utah
Corwith, H. P., vice pres., Western Union Telegraph Co., New York, N. Y.
Crosby, M. G., pres., Crosby Laboratories, Inc., Mineola, N. Y.
Deardorff, H. E., vice pres., The Dayton Power & Light Co., Dayton, Ohio
Dellis, P. L., member of management, SOFINA, Brussels, Belgium
Gardner, M. F., prof. of elec. engg., Massachusetts Institute of Technology, Cambridge, Mass.
Hartley, R. V. L., retired, 174 Summit Ave., Summit, N. J.
Huntley, H. R., telephone engr., American Tel. & Tel. Co., New York, N. Y.
Killingsworth, H. T., vice pres., American Tel. & Tel. Co., New York, N. Y.
Lytle, C. M., mgr. of engineering, Kansas City Power & Light Co., Kansas City, Mo.
McDavitt, M. B., director of switching dev., Bell Telephone Labs., Inc., New York, N. Y.
Parker, J. C., supervisor, insulation test dept., Memphis Light, Gas & Water Div., Memphis, Tenn.
Paxson, H. R., senior engr., Philadelphia Electric Co., Philadelphia, Pa.
Pease, E. I., special asst., Corps of Engineers, Seattle, Wash.
Pierce, H. J., chief engr., Northwestern Bell Tel. Co., Minneapolis, Minn.
Plumb, H. H., head, elec. div., U. S. Bureau of Reclamation, Denver, Colo.
Ransom, G. B., plant extension engr., American Tel. & Tel. Co., New York, N. Y.
Rudge, W. J., div. engr., General Electric Co., Pittsfield, Mass.
Schelkunoff, S. A., member, technical staff, Bell Tel. Labs., Murray Hill, N. J.
Tebo, J. D., science editor, Bell Tel. Labs., New York, N. Y.
Winfield, F. C., partner, Merz & McLellan, Newcastle-upon-Tyne, England

24 to grade of Fellow

To Grade of Member

Ayers, D. P., senior elec. engr., Sverdrup & Parcel, Inc., St. Louis, Mo.
Broadley, W. A., chief elec. engr., National Pneumatic Co., Boston, Mass.
Colby, H. B., system maintenance engr., Public Service Co. of Colorado, Denver, Colo.
Dempsey, J. J., Jr., distribution engr., Puget Sound Power & Light Co., Puyallup, Wash.
Doolittle, O. L., senior engr., Pacific Tel. & Tel. Co., San Diego, Calif.
Dover, R. S., sales engr., Frank W. Yarline & Co., Chicago, Ill.
Edie, L. C., engr., International Tel. & Tel. Corp., New York, N. Y.
Elam, J., asst. prof., Oklahoma A & M College, Stillwater, Okla.
Emmons, P. A., Jr., test engr., Carolina Aluminum Co., Badin, N. C.
Fink, F. P., project mgr., Watson-Flagg Engg. Co., Oak Ridge, Tenn.
Gayer, J. H., elec. advisor, Office of High Commissioner for Germany, U. S. Army, Berlin, Germany
Goobich, A., asst. elec. engr., Hetch Hetchy Power Bureau, San Francisco, Calif.
Greenwood, R. I., consulting & application engr., Westinghouse Elec. Corp., Los Angeles, Calif.
Harder, R. N., elec. engr., Aluminum Co. of America, Alcoa, Tenn.
Hoehn, A. J., Jr., elec. engr., Armour Research Foundation, Chicago, Ill.
Hovemeyer, W. E., elec. engr., navis cyclotron
Columbia University, Irvington-on-Hudson,
Iffland, J. J., engr., Capehart-Farnsworth Corp
Wayne, Ind.
Jeffers, L. M., Jr., asst. elec. engr., Public U
Comm., San Francisco, Calif.
Kelley, W. E., draftsman, Pennsylvania Rai
Philadelphia, Pa.
Kelsay, W. D., engr., Texas Power & Light Co., D
Tex.
Lantz, M. J., elec. engr., Bonneville Power Admin
tion, Portland, Ore.
Lohse, A., elec. engr., Union Oil Co. of Calif
Oleum, Calif.
Meyers, T. E., chief engr., The Wolfe & Mann
Co., Baltimore, Md.
Miller, F. E., estimates & records supervisor, P
Gas & Electric Co., Salinas, Calif.
Neu, S. S., assoc. prof. of electricity, Milwaukee S
of Engineering, Milwaukee, Wis.
O'Leary, D. F., elec. engr., Boston Edison Co., B
Mass.
Ordas, A. F., elec. engr., General Electric Co
Wayne, Ind.
Nuttall, E. D., electronic engr., United Gas Pipe
Co., Shreveport, La.
Orfanos, C. J. G., elec. engr., Ebasco Services,
New York, N. Y.
Pumphrey, R. E., div. engr., General Electric
Fort Wayne, Ind.
Schwartz, H. E., test engr., Consolidated Gas & El
Co., Baltimore, Md.
Smith, W. H., asst. engr., Toronto Hydro-El
System, Toronto, Ontario, Canada
Stannard, G. E., asst. prof. of elec. engg., Wor
Polytechnic Institute, Worcester, Mass.
Stiles, A. M., asst. prof. of elec. engg., Univers
Denver, Denver, Colo.
Vazquez-Praderi, F., chief interconnecting sy
U.T.E., Montevideo, Uruguay, So. Amer.
Webb, A. L., project engr., Bureau of Yards & D
Washington, D. C.
West, E. S., senior assoc. engr., Department of E
tion, Baltimore, Md.

37 to grade of Member

Applications for Election

Applications for admission or re-election to Ins
membership, in the grades of Fellow and Member,
been received from the following candidates, and
member objecting to election should supply a s
statement to the Secretary before February 25,
or April 25, 1951, if the applicant resides outsi
the United States, Canada, or Mexico.

To Grade of Member

Badura, C. O., Otis Elevator Co., Yonkers, N. Y.
Chapman, V. A., Logan Hardware & Supply
Huntington, W. Va.
Clover, L. E., General Elec. Co., W. Lynn, Mass.
Comstock, R. H., O. Z. Electrical Mfg. Co.,
Brooklyn, N. Y.
Dalla Verde, A., Societa' Idroelettrica Piemonte, To
Italy
Das, I. N., Damodar Valley Corp. of Bihar, India
The Kuljian Corp., Philadelphia, Pa.
Durkee, P. A., Automatic Control Co., St. Paul, M
Fich, S., Rutgers University, New Brunswick, N.
Goodmon, R. H., Virginia Elec. & Power Co.,
liamston, N. C.
Gowdy, G. A., Canton Elec. Light & Power Co., Ca
N. Y.
Gyani, G. S., P.W.D. Electricity Branch, Na
Punjab, India, c/o Westinghouse Internati
New York, N. Y.
Holmes, N., The British General Elec. Co. (Cana
Ltd., Toronto, Ontario, Canada
Jacobson, E. A., Pacific Gas & Elec. Co., Fresno,
King, L. C., Jackson & Moreland, Consulting Engi
Boston, Mass.
Kocher, S. E., Pennsylvania Power & Light
Allentown, Pa.
Lucas, F. B., University of Miami, Miami, Fla.
Mast, L. R., Electromode Corp., Rochester, N. Y.
McNeill, W. A., Cooke & Ferguson, Ltd., Manch
England
Moeller, H. M., Jackson & Moreland, Boston, Ma
Montgomery, B. E., Civil Aeronautics Admin.,
ington, D. C.
Paterson, S. G., Rogers Majestic Electronics Ltd.,
side, Ontario, Canada
Peterson, G. R., British Electricity Authority, Lo
England
Rankin, V. C., Western Elec. Co., Chicago, Ill.
Reisig, C. F. (re-election), Niagara Mohawk
Corp., Niagara Falls, N. Y.
Ruehlemann, H. E., Naval Ordnance Lab., White
Md.
Russell, J. A., Jr., Hampton Institute, Hampton,
Shobert, E. I., II, Stackpole Carbon Co., St. Mary
Silva, G., CONIEL, Rome, Italy
Swaim, B. C., Biberstein & Bowles, Inc., Cha
N. C.
Swartz, M., Greenville Utilities Comm., Gree
N. C.
Williams, J. V., Jr., I.B.M. Corp., Poughkeepsie,
Winther, M. P. (Eaton Mfg. Co.), 739 E. 140t
Cleveland, Ohio
Yanuzzi, C. A., Pennsylvania Power & Light
Allentown, Pa.

33 to grade of Member

Statement of Principles of Professional Conduct of the American Institute of Electrical Engineers

Adopted by the Board of Directors, August 4, 1950

Canons of Ethics
Foreword
Professional Life
Relations with the Public
Relations with Clients and Employers
Relations with Engineers
Code of Business Practice
Character of Enterprise with Which the Engineer Is Identified
Ownership of Engineering Data and Records
The Engineer's Relations to the Public and to the Engineering Profession
Use of Membership Designations and Institute Insignia

I. CANONS OF ETHICS FOR ENGINEERS

eing the statement developed and promulgated by the Engineers'
ncil for Professional Development, as a standard for all national
neering society groups.

word

onesty, justice, and courtesy form a moral philosophy which,
ciated with mutual interest among men, constitutes the founda-
of ethics. The engineer should recognize such a standard, not
assive observance, but as a set of dynamic principles guiding
onduct and way of life. It is his duty to practice his profession
rding to these Canons of Ethics.
s the keystone of professional conduct is integrity, the engineer
discharge his duties with fidelity to the public, his employers,
clients, and with fairness and impartiality to all. It is his duty
terest himself in public welfare, and to be ready to apply his
ial knowledge for the benefit of mankind. He should uphold
honor and dignity of his profession and also avoid association
any enterprise of questionable character. In his dealings
fellow engineers he should be fair and tolerant.

essional Life

c. 1. The engineer will coöperate in extending the effectiveness
he engineering profession by interchanging information and
rience with other engineers and students and by contributing
e work of engineering societies, schools, and the scientific and
neering press.
c. 2. He will not advertise his work or merit in a self-laudatory
ner, and he will avoid all conduct or practice likely to discredit
injury to the dignity and honor of his profession.

tions with the Public

c. 3. The engineer will endeavor to extend public knowledge
gineering, and will discourage the spreading of untrue, unfair,
exaggerated statements regarding engineering.
c. 4. He will have due regard for the safety of life and health
e public and employees who may be affected by the work for
h he is responsible.
c. 5. He will express an opinion only when it is founded on
uate knowledge and honest conviction while he is serving as a
ess before a court, commission, or other tribunal.
c. 6. He will not issue ex parte statements, criticisms, or argu-
s on matters connected with public policy which are inspired
id for by private interests, unless he indicates on whose behalf
making the statement.
c. 7. He will refrain from expressing publicly an opinion on an
eering subject unless he is informed as to the facts relating
to.

ions with Clients and Employers

c. 8. The engineer will act in professional matters for each
or employer as a faithful agent or trustee.
c. 9. He will act with fairness and justice between his client or
oyer and the contractor when dealing with contracts.

Sec. 10. He will make his status clear to his client or employer before undertaking an engagement if he may be called upon to decide on the use of inventions, apparatus, or any other thing in which he may have a financial interest.

Sec. 11. He will guard against conditions that are dangerous or threatening to life, limb, or property on work for which he is responsible, or if he is not responsible, will promptly call such conditions to the attention of those who are responsible.

Sec. 12. He will present clearly the consequences to be expected from deviations proposed if his engineering judgment is overruled by nontechnical authority in cases where he is responsible for the technical adequacy of engineering work.

Sec. 13. He will engage, or advise his client or employer to engage, and he will coöperate with, other experts and specialists whenever the client's or employer's interests are best served by such service.

Sec. 14. He will disclose no information concerning the business affairs or technical processes of clients or employers without their consent.

Sec. 15. He will not accept compensation, financial or otherwise, from more than one interested party for the same service, or for services pertaining to the same work, without the consent of all interested parties.

Sec. 16. He will not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with his client or employer in connection with work for which he is responsible.

Sec. 17. He will not be financially interested in the bids as or of a contractor on competitive work for which he is employed as an engineer unless he has the consent of his client or employer.

Sec. 18. He will promptly disclose to his client or employer any interest in a business which may compete with or affect the business of his client or employer. He will not allow an interest in any business to affect his decision regarding engineering work for which he is employed, or which he may be called upon to perform.

Relations with Engineer

Sec. 19. The engineer will endeavor to protect the engineering profession collectively and individually from misrepresentation and misunderstanding.

Sec. 20. He will take care that credit for engineering work is given to those to whom credit is properly due.

Sec. 21. He will uphold the principle of appropriate and adequate compensation for those engaged in engineering work, including those in subordinate capacities, as being in the public interest and maintaining the standards of the profession.

Sec. 22. He will endeavor to provide opportunity for the professional development and advancement of engineers in his employ.

Sec. 23. He will not directly or indirectly injure the professional reputation, prospects, or practice of another engineer. However, if he considers that an engineer is guilty of unethical, illegal, or unfair practice, he will present the information to the proper authority for action.

Sec. 24. He will exercise due restraint in criticizing another engineer's work in public, recognizing the fact that the engineering societies and the engineering press provide the proper forum for technical discussions and criticism.

Sec. 25. He will not try to supplant another engineer in a particular employment after becoming aware that definite steps have been taken toward the other's employment.

Sec. 26. He will not compete with another engineer on the basis of charges for work by underbidding, through reducing his normal fees after having been informed of the charges named by the other.

Sec. 27. He will not use the advantages of a salaried position to compete unfairly with another engineer.

Sec. 28. He will not become associated in responsibility for work with engineers who do not conform to ethical practices.

II. CODE OF BUSINESS PRACTICE

Being those principles contained in the original code of the Institute not covered by the Canons of the Engineers' Council for Professional Development.

Character of Enterprise with Which the Engineer is Identified

Sec. 1. It is the duty of the engineer to satisfy himself to the best of his ability that the enterprises with which he becomes identified are of legitimate character. If after becoming associated with an enterprise he finds it to be of questionable character, he should sever his connection with it as soon as practicable.

Ownership of Engineering Data and Records

Sec. 2. It is desirable that an engineer undertaking for others work in connection with which he may make improvements, inventions, plans, designs, or other records, should enter into an agreement regarding their ownership.

Sec. 3. If an engineer uses information which is not common knowledge or public property, but which he obtains from a client or employer, the results in the form of plans, designs, or other records, should not be regarded as his property, but the property of his client or employer.

Sec. 4. If an engineer uses only his own knowledge, or information which by prior publication, or otherwise, is public property and obtains no engineering data from a client or employer, except performance specifications or routine information, then in the absence of an agreement to the contrary the results in the form of inventions, plans, designs, or other records, should be regarded as the property of the engineer, and the client or employer should be entitled to their use only in the case for which the engineer was retained.

Sec. 5. All work and results accomplished by the engineer in the form of inventions, plans, designs, or other records, that are outside of the field of engineering for which a client or employer has retained him, should be regarded as the engineer's property unless there is an agreement to the contrary.

Sec. 6. When an engineer or manufacturer builds apparatus from designs supplied to him by a customer, the designs remain the property of the customer and should not be duplicated by the engineer or manufacturer for others without express permission. When the engineer or manufacturer and a customer jointly work out designs and plans or develop inventions, a clear understanding should be reached before the beginning of the work regarding the respective rights of ownership in any inventions, designs, or matters of similar character, that may result.

Sec. 7. Any engineering data or information which an engineer obtains from his client or employer, or which he creates as a result of such information, may be considered confidential by the engineer; and while he is justified in using such data or information in his own practice as forming part of his professional experience, its publication without express permission is improper.

Sec. 8. Designs, data, records, and notes made by an employee and referring exclusively to his employer's work, should be regarded as his employer's property.

Sec. 9. A customer, in buying apparatus, does not acquire any right in its design but only the use of the apparatus purchased. A client does not acquire any right to the ideas developed and plans made by a consulting engineer except for the specific case for which they were made.

The Engineer's Relations to the Public and to the Engineering Profession

Sec. 10. It is desirable that the first publication concerning inventions or other engineering advances should not be made through the public press, but before engineering societies or through technical publications.

Sec. 11. It is unprofessional to give an opinion on a subject without being fully informed as to all the facts relating thereto and as to the purposes for which the information is asked. The opinion should contain a full statement of the conditions under which it applies.

Sec. 12. An engineer in responsible charge of work should not permit non-technical persons to overrule his engineering judgments on purely engineering grounds.

III. USE OF MEMBERSHIP DESIGNATIONS AND INSTITUTE INSIGNIA

Sec. 13. The use of a membership designation, such as Fellow, Member, Associate, or Honorary Member, is a purely personal privilege of the individual member. It may be used with the member's name on stationery and in any ethical professional advertising. But a corporation, association, or firm may not itself use any membership designation because of the individual membership status possessed by a representative of a corporation, association, or firm.

Sec. 14. Insignia of the Institute, that is, any symbol such as imprint of the badge design, or a heading such as "American Ins tute of Electrical Engineers," should be used only for Institu business and publications. The personal use of Institute insig by a member should be limited to wearing an officially issued bad of the appropriate grade.

HISTORY OF THE CANONS AND CODE

THE INSTITUTE CODE

At the Milwaukee convention in May 1906, Dr. Schuyler Ska Wheeler delivered his presidential address on "Engineering Hono It was the sense of the convention that the ideas contained in t address should be embodied in a Code of Ethics for the electri engineering profession, and to this end the following committee w appointed in October 1906:

Schuyler Skaats Wheeler, *Chairman*

H. W. Buck
Charles P. Steinmetz

In May 1907, the committee reported a code to the President a Board of Directors for discussion at the June convention at Niaga Falls. It was discussed and approved by the convention, and was taken up by the Board of Directors on August 30, 1907, revis printed, and submitted to the membership for suggestions to sent to a new committee appointed by President Stott.

In June 1911, in accordance with a resolution of the Board Directors, President Jackson reappointed a committee which w assisted by eighteen advisory members, as follows:

William S. Barstow
Louis Bell
John J. Carty
Francis B. Crocker
Dugald C. Jackson
A. E. Kennelly

John W. Lieb. Jr.
C. O. Mailloux
Ralph D. Mershon
Henry H. Norris
Ralph W. Pope
Harris J. Ryan

Charles F. Scot
Samuel Sheldon
William Stanle
Lewis B. Stillw
Elihu Thomson
W. D. Weaver

This committee's work was presented in a report to the Board Directors on February 9, 1912, when the code was tentativ adopted and the title of the committee and of the code was chang from that of Code of Ethics to Code of Principles of Professio Conduct. After a month's careful analysis and consideration numerous suggestions from the advisory members of the commit and others, the completed code was adopted at the meeting of Board of Directors on March 8, 1912.

On March 17, 1922, the Board of Directors adopted resoluti re-affirming adherence to the code, and providing that it shall be duty of the Committee on Code of Principles of Professional Cond to advise inquirers respecting questions of proper professional c duct, and to investigate and report upon any practice of a member this Institute which might be prejudicial to the welfare of the stitute, the engineering profession, or the community.

Since 1912 the following have served as members of the Co mittee on Code of Principles of Professional Conduct:

C. A. Adams
P. L. Alger
R. E. Argersinger
A. H. Babcock
Harry Barker
H. H. Barnes, Jr.
C. R. Beardsley
B. A. Behrend
H. W. Buck
H. V. Carpenter
H. P. Charlesworth
L. W. Chubb
Edith Clarke
Gano Dunn
F. F. Evenson
D. D. Ewing
G. Faccioli
E. S. Fields
E. H. Flath
J. C. Forsythe
N. E. Funk

H. B. Gear
Harold Goodwin, Jr.
Carl A. Heinze
F. B. Jewett
John F. Kelly
W. B. Kouwenhoven
W. S. Lee
John W. Lieb
H. P. Liversidge
A. M. MacCutcheon
R. D. Maxson
A. S. McAllister
R. D. Mershon
E. B. Meyer
W. E. Mitchell
L. F. Morehouse
E. L. Moreland
S. H. Mortensen
H. N. Muller
Farley Osgood
John C. Parker

M. Penn
W. M. Piatt
H. T. Plumb
Harris J. Ryan
H. R. Sargent
A. M. Schoen
R. F. Schuchardt
George F. Sever
C. E. Skinner
Harold B. Smith
Walter Charles Smith
R. W. Sorensen
C. E. Stephens
L. B. Stillwell
John B. Taylor
G. A. Waters
James S. Waters
Schuyler Skaats Whee
J. B. Whitehead
W. E. Wickenden
H. S. Wynkoop

THE CANONS OF THE ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

A project for a uniform statement of ethics to be formally adop in the American engineering world was first organized under auspices of the American Engineering Council, with Dugald Jackson as Chairman of a special committee. The Council was solved in 1940 but the Engineers' Council for Professional Devel ment had come into existence and took on the responsibility for committee which continued with Dr. Jackson as Chairman dow 1948. This committee was made up of a representative of each

eight constituent societies of the Council plus the American
ute of Consulting Engineers.

committee in 1942 came to agreement on a formulation of
s of Ethics consisting of 31 items. This was approved by the
il and forwarded to the constituent societies with the request
ach society through its Board should give the Council its views
Canons. The American Institute of Electrical Engineers and
ational Council of State Boards of Engineering Examiners ap-
d the Canons in principle. The Council of the American In-
e of Consulting Engineers advanced changes in phraseology
arrangement of items, which statement was then referred to
e Alternative Draft. The American Society of Mechanical
eers accepted the Canons in principle with a preference for the
ative Draft. The American Society of Civil Engineers ap-
d in principle a committee draft similar to the Alternative.
Engineering Institute of Canada approved a draft largely
ed on the alternatives. In April 1947, the Committee of the
cil adopted the statement of the Engineering Institute of
da (which society had the benefit of the preceding years of dis-
n before making its formulation) with some slight modi-
ns. The Executive Committee of the Council approved this
statement and recommended to its constituent societies that it be adopted. The Council in October 1947, in accordance with the assent of seven of the eight constituent societies adopted the revised Canons as the official formulation for the engineering field, and recommended its adoption by the separate societies.

The Board of Directors of the American Institute of Electrical Engineers adopted the revised Canons on November 5, 1947, advising its Committee on Principles of Professional Conduct to revise the Institute's old Code to accord with such action.

The "Statement of Principles of Professional Conduct," as above printed, was recommended to the Directors by the 1949–1950 Institute Committee embodying the Canons and supplementing them with certain rules of business practice from the old code not embodied in the Canons. The Statement was adopted by the Directors on August 4, 1950.

The "Canons of Ethics for Engineers," Part I of this statement, printed on rag paper in a size, 9 inches by 14 inches, suitable for mounting, may be purchased from Engineers' Council for Professional Development, 29–33 West 39th Street, New York 18, N. Y., at a price of 50¢ each—35¢ in lots of ten or more. Please include remittance with order.

OF CURRENT INTERES

New System of Handling Correspondence by Remote Control Dictation Is Announced

In a new approach to handling business correspondence, Thomas A. Edison, Inc., has developed a new system of "remote control" dictation. The TeleVoice System, as it is called, consists of from 1 to 20 modified telephones directly connected to a central recording instrument located near the secretary.

The recording instrument, called the Edison TeleVoicewriter, records the dictation received on plastic discs. Transcription of the dictated matter is accomplished with the standard disc.

The TeleVoice Stations (phone extensions) can be located any distance from the TeleVoicewriter. Each station gives the dictator every one of the services he needs to dictate, including a means of listening back to what he has said and the facility for recording corrections.

Unlike individual dictating machines, the dictator has only those functions to perform which are a direct part of actual dictation. The secretary takes care of changing the discs and index slips. Since the work is delivered to her by direct wire, her flow of work is even and messenger services are minimized. A positive warning signal in the form of a small red light on each phone goes on when the system is being used, making it unnecessary to pick up the receiver and listen to find out if all is clear.

The result is a well-integrated system for business dictation—a dictating system that because of its low cost (only half that of individual machines) makes possible instrument dictation service to every letter or memo writer even though his daily output may be very small.

TeleVoice Stations (extensions) are made in both desk-type and mount-type phones. On each phone base is just one button and the signal light. This button is used both for making corrections and for listening back. In the handle is a "talk switch" that is held down during dictation; it starts and stops the disc on the TeleVoicewriter recording instrument. The dictator records correction marks on the index slip by pressi
button located on the base of the Tele
extension while holding the "talk"
down. To listen back the dictator
the base button only. Length mar
the index slip are automatically record
"hanging up." While as many
TeleVoice Stations can be wired t
TeleVoicewriter recorder, the averag
commercial installations is ten.

A typical installation of Edison TeleVoice Stations for remote control dictation. Man in foreground is shown dictating at one of the TeleVoice Stations in the department pictured. A modified telephone instrument, the TeleVoice station provides the dictator with all the control he needs for dictation, and it automatically records the length of dictation on hanging up

William P. Lear Winner of the Collier Trophy for 1950

William P. Lear has been name
recipient of the 1950 Robert J.
Trophy for " . . . the greatest achiev
in aviation in America during the pr
year," by the National Aeronautic A
tion in Washington, D. C.

Mr. Lear, Chairman of the Boa
Directors and Director of Research
Development of Lear, Inc., Grand R
Mich., Los Angeles, Calif., and
Ohio, received the award from the Pre

Future Meetings of Other Soci

American Concrete Institute. 47th Annual
vention. February 20–22, 1951. St. Francis
San Francisco, Calif.

American Material Handling Society. M
Handling Conference held concurrently with t
tional Materials Handling Exposition. April 3
4, 1951. International Amphitheatre, Chicago,

American Society for Testing Materials.
Meeting. March 5–9, 1951, Cincinnati, Ohio.

American Society of Tool Engineers. Annual
ing. March 15–17, 1951, Hotel New Yorker
York, N. Y.

Conference on Industrial Personnel. March
1951, Columbia University, New York, N. Y.

Fourth Annual Conference for Protective
Engineers. March 26–28, 1951, Agricultur
Mechanical College of Texas, College Station,

Institute of Radio Engineers. Annual Con
March 19–22, 1951, Waldorf Astoria Hotel and
Central Palace, New York, N. Y.

Institute of the Aeronautical Sciences. 19th
Meeting. January 29–31 and February 1, 1951
Astor, New York, N. Y.

Instrument Society of America. Conference
held by the Pittsburgh Section and the Carne
stitute of Technology. March 28–29, 1951.
burgh, Pa.

Midwest Power Conference. 14th Annual
ference. April 4–6, 1951. Sherman Hotel, C
Ill.

National Association of Corrosion Engineers.
13–16, 1951, Hotel Statler, New York, N. Y.

Pennsylvania Electric Association. Prime
Committee. March 8–9, 1951. Berkshire
Reading, Pa.

Pennsylvania Electric Association. Winter
of Transmission and Distribution Committee
ruary 1–2, 1951, William Penn Hotel, Pittsburgh,

Society of Motion Picture and Television Eng
Spring Convention. April 30–May 4, 1951.
Statler, New York, N. Y.

Society of the Plastics Industry. Sixth Annua
nical Session. February 28 and March 1–2,
Edgewater Beach Hotel, Chicago, Ill.

f the United States " . . . for his outstanding chievement in the development, perfection, pplication and production of the Lear F-5 utomatic Pilot and Automatic Approach ontrol Coupler System, which makes posble the safe landing of jet aircraft regardless f extreme weather or visibility conditions."

The Lear system consists of a small, ghtweight, automatic pilot capable of ontrolling a supersonic jet fighter, and an utomatic approach control coupler which ooks the jet plane onto the Government's andard Instrument Landing System beam. he All-Weather Flying Command of the Jnited States Air Force at Patterson Field, nder whose auspices Lear developed the utomatic approach control coupler system, as rigorously tested it since 1949 under perating conditions, and found it to be a ecessity in completing zero-zero weather ndings, making all-weather interception perations practical.

The Lear F-5 automatic pilot is the first o be accepted for use in jet fighter-type ircraft, and has given the Air Force a olution to the problems of operationally afe night flight, blind flight, automatic acking, and all-weather landing of these ircraft.

It is an electromechanical device which utomatically holds an aircraft on any predetermined course at any altitude, and will lso allow the pilot to make alteration of his course at will. Turns are co-ordinated, ying fast or slow or in any angle of climb or ive. It is made up of three main parts vhich closely parallel a human pilot's ontrol system. The gyroscopes are the -5's eyes; they sense any deviation from he course or altitude. The amplifier is he brain which controls the servomechanisms vhich are the muscles that apply the force o the control surfaces of the aircraft. There re three sets of eyes, three sets of brains, nd three sets of muscles.

The Lear F-5 automatic pilot provides in ddition three extras which monitor the peration. One is the automatic trim tab vhich keeps the manual trim tab adjusted o the position so that the main servoechanism has the least work to do, and olves the problem of airplane trimming so hat whenever the F-5 is turned off, the jet oes not dive or climb. Another controls he directional gyro so that it always points o the proper magnetic direction. This nables the ship to fly a straight magnetic eading. The third extra keeps the ship at ny selected altitude. All these are supplemented by the two vital course steerers vhen making an automatic Instrument Landing System let-down to the runway, r automatic approach and landing. One f these keeps the jet on the localizer or orizontal path, and the other keeps it sliding own the vertical or glide path right to the unway.

Karl T. Compton Presented the Hoover Medal for 1950

Karl T. Compton, Chairman of the Corporation of the Massachusetts Institute of Technology, Cambridge, Mass., has been awarded the Hoover Medal for 1950. The Medal, established through a trust fund created by the gift of Conrad N. Lauer, is to be awarded periodically by a Board of Award, composed of representatives of the national societies of Civil, Mining, Mechanical, and Electrical Engineers, "to a fellow engineer for distinguished public service." The first award was made in 1930 to President Herbert Hoover to commemorate his civic and humanitarian achievements. Doctor Compton is a fellow of the AIEE.

The Lear F-5 autopilot as installed on the instrument panel of a Twin Beech showing controller and automatic approach control coupler. Lear Dual ADF-12 and Lear VHF receiver and transmitter combined with low-frequency range and broadcast receiver is shown above on the instrument panel

Alfred Noble Prize Awarded to Kochenberger for Best Paper

The Alfred Noble Prize for a technical paper of exceptional merit this year was awarded to Ralph J. Kochenburger, assistant professor of electrical engineering, University of Connecticut, Storrs, Conn., and a member of the American Institute of Electrical Engineers, for his outstanding research paper "A Frequency-Response Method for Analyzing and Synthesizing Contactor Servomechanisms."

This prize was established in 1929 and consists of a cash award from the income of a fund contributed by engineers and others in honor of the late Alfred Noble, Past President of the American Society of Civil Engineers and of the Western Society of Engineers, for the purpose of perpetuating his name and achievements.

The award is made to a member of any grade of the AIEE, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, or the Western Society of Engineers, for a technical paper of exceptional merit accepted for publication in any of their technical publications, provided the author has not passed his thirty-first birthday at the time the paper is submitted. The award is based on papers published by each society within the 12 months preceding June 1 of each year. Papers prepared by joint authors are not eligible.

The amount of the prize is determined by resolution of the Board of Directors of the American Society of Civil Engineers. The award this year is approximately $350.

Vannevar Bush Receives John Fritz Medal for 1950

The John Fritz Medal for 1950 has been awarded to Vannevar Bush, President of the Carnegie Institution of Washington, Washington, D. C., "for his outstanding scientific contributions to his country and to his fellow men."

The Medal is awarded annually by a board composed of four representatives of each of the four national engineering societies, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society of Civil Engineers, for notable scientific or industrial achievements, regardless of nationality or sex. It was established by professional associates and friends of John Fritz on August 21, 1902, to perpetuate the memory of his achievements in industrial progress. The first award of the Medal was made to John Fritz at a dinner given on his 80th birthday August 21, 1902.

Former recipients have included George Westinghouse, Alexander Graham Bell, Orville Wright, Thomas A. Edison, Herbert Hoover, Charles F. Kettering, Alfred Noble, and Guglielmo Marconi.

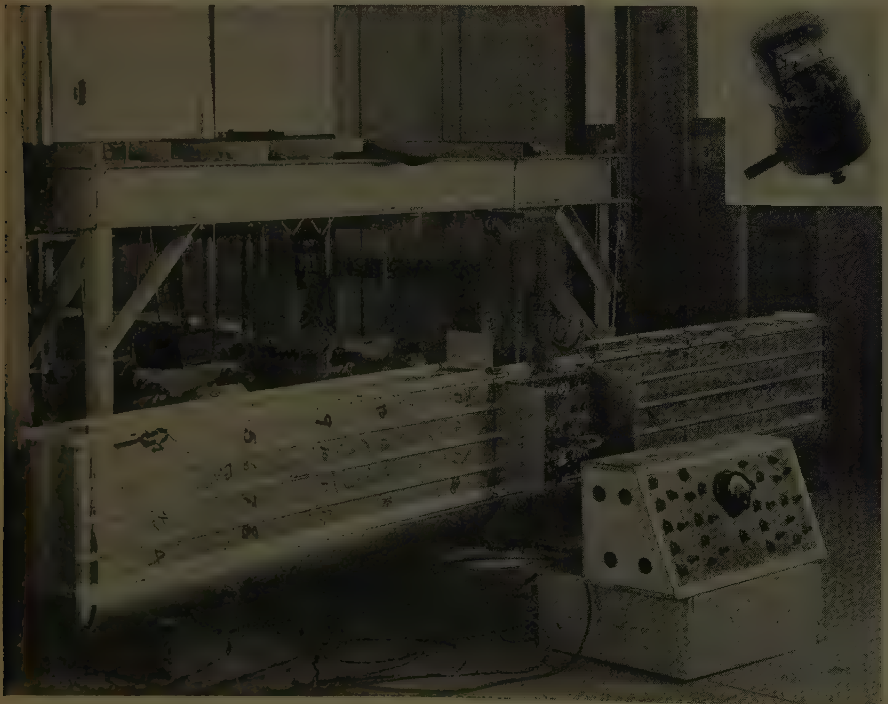
Improved Ramberg Vacuum-Tube Accelerometer Developed by NBS

Recent research in the Engineering Mechanics Section of the National Bureau of Standards (NBS) has resulted in an improvement of the Ramberg vacuum-tube accelerometer which NBS developed in 1946 for the Navy's Bureau of Aeronautics with the co-operation of Sylvania Electric Products, Inc. The new pickup provides more sensitive and reliable acceleration measurements than did the earlier version which, despite slight erratic changes during its operation, has been successfully applied to both field and laboratory acceleration measurements. Among such uses have been acceleration measurements on pilot ejection devices for high-speed aircraft, in landing impact tests for model aircraft, as well as on aircraft in actual flight.

The vacuum-tube acceleration pickup is a twin-diode consisting of a fixed, indirectly heated cathode and two plates, one on each side of the cathode. The plates are elastically mounted so that they will be deflected if the base of the tube is accelerated in a direction perpendicular to the plane of the plates. The new model differs from earlier versions in having stops to limit the motion of the plates, support rods 0.010 inch in diameter to increase the sensitivity of the tube, and a second getter.

The primary design requirement met by the Ramberg vacuum-tube accelerometer is its provision for an electric signal of sufficient strength to drive directly a high-frequency recording galvanometer and at the same time have a relatively high natural vibration frequency. In the operation of the original model erratic changes or "zero shifts" in its balance point were sometimes encountered. The source of this difficulty has been eliminated in the new model. The zero shift, resulting from excessive accelerations to the pickup while handling and installing, is prevented by stops which were added to limit the plate excursion and thus prevent overloading. "Zero drift," believed to be due to small fluctuations in the cathode electron emission, has been effectively reduced by three steps: 1. the accelerometer was given an aging treatment which made its emission nearly constant; 2. two "getters" instead of one were used to improve the electrical characteristics; 3. the sensitivity was increased by a factor of 25 to make the remaining random output negligible compared with the output due to acceleration.

Because of promising results obtained wit both the original and improved tube, a extended developmental project on th fundamentals of acceleration measurements i now under way as part of the NBS progra on basic instrumentation, which is co-operatively supported by the Office of Naval Research, the Office of Air Research, and th Atomic Energy Commission. The objectives of this project are to obtain accelerometers having a greater range of acceleratio measurement, higher output voltages, an damping of the natural frequency response.



The improved Ramberg vacuum-tube accelerometer (see inset) being used for measuring the amplitude of vibration at a natural frequency of this structural model of an airplane wing. The accelerometer at the wing tip is used to keep the vibration at a constant level; the other accelerometer is moved from station to station to measure the variation of vibration amplitude with position along the length of the model

New Electrical Components Developed by Air Force

The development of a new high-temperature tantalum capacitor with longer lif and better electrical characteristics wa announced recently by Electronic Subdivision engineers at Air Materiel Comman Headquarters, Wright-Patterson Air Forc Base, Dayton, Ohio.

Operation of the new unit is now possibl from −60 degrees centigrade to +17 degrees centigrade. This is a significan performance advance over presently available electrolytic capacitors which are no operable beyond a range of −40 degrees t +85 degrees centigrade. The new capacito also boasts a shelf life of from five to eigh years as compared to the normal 12- to 18 month life of the currently used capacitor.

At −60 degrees centigrade, less tha 15 per cent of the capacitance is lost in th new piece of electronic equipment. This i due to the tantalum electrodes on which i formed tantalum oxide, a more stabl product than the aluminum oxide formatio used on old-type capacitors. From 50 t 70 per cent of the electrical capacitance wa lost in the aluminum electrolytic capacito at −40 degrees centigrade.

A precision-type resistor that hits ne peaks in stability and efficiency also has bee developed by the Air Materiel Command's Electronic Subdivision. Ordinary wire wound or composition resistors have a temperature coefficient ranging from 1 to 2 per cent, depending on environment. Th new, more stable high-temperature deposite carbon resistor varies less than 0.1 per cent A special high-temperature protective paint which acts as an oxygen barrier, enable full lead operation at temperatures rangin up to 200 degrees centigrade. The ol type resistors could not operate in temperatures higher than 70 to 85 degrees centigrade

The new resistor is also lighter an stronger than its predecessors. A cerami base that replaces the old type porcelai base bolsters strength, although the ne resistor is much smaller than either the wire wound or composition type. —

Election of Ralph J. Cordiner As New G.E. President

The election of Ralph J. Cordiner o New York as President of the Genera Electric Company to succeed Charles E Wilson, who has been named Chairman o the new Defense Mobilization Board, wa ounced recently. The retiring president pleted 51 years of continuous service General Electric in November. Start- in 1899 as a messenger boy with the ague Electric Company, later to become art of General Electric, he rose to the idency in 1939. He served as vice- rman of the War Production Board in shington from 1942 until 1943, and then named executive vice-chairman with authority over all war production, ing in that post until 1944.

e resigns also as Chairman of the Board eneral Electric Supply Corporation and member of the board of directors of rnational General Electric Company the Guaranty Trust Company.

Ir. Cordiner was graduated from Whit- College in 1922. His first position after luation was as commercial manager division of the Pacific Power and Light npany. In less than a year he was ed a position with the Edison General tric Appliance Company with head- ters in Portland. Five years later he me Northwest manager in Portland in 1930 moved to San Francisco to be- e Pacific Coast division manager.

hen the heating device section of the on General Electric Appliance Com- was transferred from Chicago and olidated with General Electric's Ap- nce and Merchandise Department at geport in 1932, Mr. Cordiner went with ection as manager and chairman of the agement committee. Two years later was appointed assistant manager of iance sales, and in 1935 became manager e radio division. A year later he was noted to assistant manager of the Ap- nce and Merchandise Department, and anuary 1938 succeeded Mr. Wilson as ager of the department.

1942, Mr. Cordiner entered govern- service as director-general of war uction scheduling and vice-chairman of War Production Board. He rejoined eral Electric as assistant to the president 943 and was elected Vice-President in uary 1945. He assumes immediately ew duties as President.

lications for 1951 Sloan ellowships Due in February

urteen young business executives will warded Sloan Fellowships in 1951 for cipation in an Executive Development ram at Massachusetts Institute of nology (MIT). These fellowships, ded to outstanding young executives nation-wide competition, cover a year vanced study in economics and business nistration at MIT and are aimed at ring men for higher executive re- ibility.

is program of broad and high level ation toward managerial leadership, ted 20 years ago by MIT's Department siness and Engineering Administration, the pioneer program of its kind. Its nuance has been made possible by s of funds from the Alfred P. Sloan dation and by the support of com- s who sponsor outstanding young men provide a leave of absence for a year. onsorship by an employer is a pre- site of this program. The candidates will be drawn from both large and small companies in various types of industry throughout the country. The winners of the fellowships will participate in a special program consisting of seminars, classes, and field investigations aimed not only at increasing technical managerial skill, but also their understanding of the social and economic implications of their work.

Applications for the awards must be made by February 24, 1951. Recipients will be selected on a competitive basis by MIT after consideration of the applicants' records and references, and consultation with their employers. Awards range up to $3,720 for married men and up to $2,720 for those who are single. Fellows will be in residence at MIT in Cambridge from June 1951 to June 1952. Applicants must be between the ages of 30 and 35 and have at least five to ten years of industrial experience, part of it in an executive capacity.

The largest recorded value of short-circuit current, the equivalent of 12,000,000 kva symmetrical 3-phase, was used in testing this single-pole unit of one of the 13 oil circuit breakers at the Grand Coulee Dam project

Short-Circuit Tests Set New Record at Grand Coulee Dam

A new record for short-circuit current was set recently during a series of tests conducted by the General Electric Company and the United States Bureau of Reclamation at Grand Coulee Dam. The tests were made on a single-pole unit of one of the 13 10,000,000-kva 230-kv low-oil-content impulse-type oil circuit breakers now installed in the right-hand switchyard of the Grand Coulee project. The generating capacity of 12 of the 14 108,000-kw generators at Grand Coulee, plus the available capacity of other stations of the Northwest Power Pool, were introduced into the tests to produce the largest value of short-circuit current ever recorded, the equivalent of 12,000,000 kva symmetrical 3-phase.

Even this enormous amount of short-circuit current was interrupted by the 10,000,000-kva circuit-breaker unit within its rated interrupting time of three cycles without any sign of distress.

A total of 12 interrupting- and 24 line-dropping tests were made, all of which were entirely successful. The interrupting tests ranged from 5,000,000 to 12,000,000 kva and four of them, ranging from 6,000,000 to 9,000,000 kva, were high-speed reclosing tests with reclosing times between 8.75 and 9.2 cycles. The line-dropping tests, all of which were accomplished without the occurrence of a single restrike, were made with from 100 to 300 miles of 230-kv transmission line. Inspection afterward revealed that all parts of the circuit breaker were in condition to continue normal operation and the unit could have withstood many additional tests.

An elaborate instrumentation equipment devised by the General Electric Company's Switchgear Divisions' Laboratory was used to record the tests in much more complete form than has been possible previously.

New Facsimile System Developed by RCA for Oak Ridge Laboratory

A test model of a new high-speed, long-distance facsimile system, developed by the Radio Corporation of America (RCA)

Laboratories, Princeton, N. J., under contract with the Atomic Energy Commission, has been installed at the Oak Ridge National Laboratory for providing full reference library service to outlying research laboratories.

The new system incorporates several innovations in the field of facsimile reproduction. The reader-transmitter will scan printed copy or drawings on flat surfaces such as book pages and will make direct enlargements of material in small type by any ratio up to four to one. The copy bed can handle individual sheets or books up to three inches thick. The signal is transmitted over an ordinary telephone line and the recorder will reproduce clear, highly legible black-on-white copy at a speed of 15 linear inches or 120 square inches per minute.

Operational tests to be started at Oak Ridge immediately will indicate to what extent existing library services at the Laboratory can be expanded without greatly increasing the outlay for new books and particularly scarce and expensive sets of bound scientific periodicals. The system also will prevent possible contamination of books and journals in laboratories using radioactive materials.

At the present time at Oak Ridge, more than a score of separate research and production facilities scattered over a wide area require library services. If the new facsimile service proves useful, it may be possible to consolidate many of these library services into larger, more adequate units.

A cathode-ray flying-spot scanner at the sending unit is the most important innovation. The 5-inch cathode-ray tube directs a tiny spot of light through a focusing lens to "read" the copy in a thin line from left to right. The reflected light from the copy is picked up by a bank of four photomultiplier tubes which convert the varying light impulses into normal electric facsimile signals.

The copy bed automatically moves the copy forward under the flying-spot cathode-ray tube. The length of the scanning line on the copy can be adjusted from $2^{1}/_{16}$ to $8^{1}/_{2}$ inches by simply turning a knob. This automatically adjusts the lens to maintain the proper focus and the same adjustment changes the speed of the copy bed to maintain the correct scale.

The receiver, or recorder, also incorporates several new mechanical and chemical features to simplify operation and to supply a permanent print of the transmitted material. The electrolytic process used in recording eliminates photodeveloping and printing and avoids clogging and corrosion of previous electrolytic methods. The paper is moistened no more than is absolutely necessary, and as it passes out of the machine it is completely dried. Ultraviolet light fixes the chemicals so that neither the printing nor the background will fade. The clogging and corrosive action of the chemical solution is eliminated by keeping separate the two components until applied to the paper.

Westinghouse Gets $20,000,000 Wind Tunnel Order

The Westinghouse Electric Corporation has received an order from the United States Air Force for $20,000,000 worth of electric equipment for a new wind tunnel to test full size jet engines, guided missiles, and wing sections and fuselages of aircraft.

The wind tunnel will be built at the Arnold Engineering Development Center, Tullahoma, Tenn. The Center houses important aeronautical research facilities available not only to the Air Force, Army, and Navy but also to all parties in government, industry, and science interested in aircraft development. It was renamed recently in honor of the late General H. H. "Hap" Arnold, wartime head of the Army Air Force.

Of four big electric motors to be built for the new tunnel, two will be the most powerful in the world, exceeding the 65,000-horsepower rating of the motors now in service at Grand Coulee Dam in the state of Washington. The motors and switchgear for their control will be built at the Westinghouse plant in East Pittsburgh, Pa.

The Sunnyvale, Calif., plant will make a big air compressor to push air through the tunnel at speeds up to and above the speed of sound. The compressor will be the world's largest rotating machine.

"Anaerobic Permafil" New Material Developed by G.E.

A material which remains liquid as long as a stream of air bubbles through it, but which hardens in a few minutes when away from air, has been developed in the chemistry divisions of the General Electric Research Laboratory. Its properties are thus opposite to those of paint, which hardens when exposed to air.

This new material is able to penetrate extremely small cracks before hardening. Thus, a possible application is a tight seal for stopping nearly invisible leaks, or a "pipe dope" for sealing threaded unions. The laboratory scientists responsible for the new development are Dr. Robert E. Burnett and Birger W. Nordlander.

They call the substance "anaerobic permafil," borrowing a word from the biologists. The term "anaerobic" means "non-airliving," and it is used by bacteriologists to designate organisms that remain inactive in the presence of air, but which thrive and propagate when air is absent.

Anaerobic permafil remains liquid as long as it is aerated. When away from air it solidifies quickly, without heating, or adding catalysts and accelerators. When two metal strips are coated lightly with it and clamped together the joint will support ten pounds after ten minutes. After 20 hours, it will hold 100 pounds. If still faster hardening is desired, the permafil may be heated up to 212 degrees Fahrenheit and solidification takes place in a minute or less.

Engineering Curricula and Programs Accredited by ECPD

The work of accrediting undergraduate engineering curricula and the programs of the technical institute type in the United States has been continued by the Educational Committee (formerly the Committee on Engineering Schools) of the Engineers Council for Professional Development (ECPD). The work of accreditation has received wide acceptance by the schoo
the profession, and the public.

As of October 20, 1950, ECPD ha
accredited 656 engineering curricula repr
senting 142 different schools with accredit
curricula. Some 50 programs of the tec
nical institute type have been accredited
19 technical institutes.

The complete list of accredited unde
graduate engineering curricula by instit
tions and by curricula as well as the list
accredited programs of technical institu
type has been made available by ECPD
a 20-page pamphlet with statements of t
objectives and procedure of accreditin
this list may be purchased at a price
25¢ each. Please address all orders
ECPD, 29–33 West 39th Street, New Yo
18, N. Y., and include remittance with orde

Armour Research Foundation to Offer Fellowships in 1951

Armour Research Foundation of Illin
Institute of Technology is offering a numb
of industrial research fellowships in physi
chemistry, metallurgy, ceramics, mechani
and electrical engineering to begin
September 1951. Those persons award
fellowships will attend Illinois Institute
Technology half-time and work in t
Research Foundation half-time in a gradua
program leading to advanced academ
degrees. They are employed full-time
the Foundation during the summer.

Fellowships begin at the start of the scho
semester and continue through the summ
for approximately 21 months until the e
of the second academic year. Awards a
made on a competitive basis to United Stat
citizens under 28 years of age holding
bachelor's degree from an accredited eng
neering or scientific school or liberal a
college with a major in the sciences.

In addition to tuition, fellows receive $1
a month during the first academic yea
$275 a month and a 2-week vacation duri
the summer, and $175 a month during t
second academic year. The Foundati
awarded five fellowships in 1950. Applic
tion forms may be obtained from the Offi
of Admissions, Graduate School of Illin
Institute of Technology, Chicago, I
Applications received prior to March 15 w
be given first consideration.

Indian Engineers Return Home After Training Course in U.S.

After a ten months' visit and intensi
training course in this country, a group
11 engineers sent here by the Government
India have returned home to apply Ame
can methods to a vast new power proje
in their native land. They will form t
chief members of the engineering staff whi
will operate the new Bokaro Steam Pow
Plant in the Damodar Valley project, o
of the largest ever undertaken in the East.

The training of the group during th
stay here was supervised by The Kulji
Corporation of Philadelphia, Pa., to who
the Indian Government has awarded t
contract for the design, engineering, a
construction of the Bokaro Steam Pow
Plant. In addition to their course of traini

he Kuljian headquarters in Philadelphia, engineers studied operating methods at r a dozen large utility plants in the East l Middle West. They also visited the neral Electric plant in Schenectady, and er manufacturing plants supplying the jor equipment for the Bokaro Station.

n their return to Bokaro, the engineers work closely with the Kuljian staff now ervising the construction of the plant. vill include a series of eight dams along the modar River. The objects are very ilar to those of our Tennessee Valley thority project: to provide the benefits rrigation, flood control, and cheap power an immense area. For one year after s completed, the plant will be operated American personnel in the Kuljian rporation's employ. Then the operation he plant will be turned over to the Indian ineers.

th of the Engineer. Printed statements "Faith of the Engineer" on rag paper a size 17 inches by 22 inches suitable for unting are available in a limited quantity n the Engineers' Council for Professional velopment, 29–33 West 39th Street, v York 18, N. Y., at a reduced price of 00. Please include remittance with order.

nois Engineering Council Elects Officers

lois W. Graf, Chicago patent lawyer member of the Institute of Radio ineers and the Illinois Society of Proonal Engineers, was named president of latter organization for 1951. G. C. ghlin of the Commonwealth Edison npany and The American Society of chanical Engineers is first Vice-President. ond Vice-President is R. A. Lonier of Illinois Association of Highway Engirs. John A. Harrington of the Illuminat- Engineering Society is Secretaryasurer. K. V. Glentzer of AIEE, R. R. telsmeyer of Belleville and the Illinois ociation of County Superintendents of hways, and Norman Gundrum of Spring- and the American Society of Civil ineers, are members of the Executive nmittee.

he Illinois Engineering Council, comd of 16 engineering societies, is active civic and governmental matters pering to the engineers' professional insts. It makes recommendations for ointments to the examining boards for stration under the Structural and Regisd Professional Engineering Acts.

ool of Reactor Technology Receiving Applications

pplications are now being received by Oak Ridge School of Reactor Techgy for enrollment in the 1951–52 session, nning September 10, 1951. This school established at the Oak Ridge National oratory in March of 1950 under sponsor- of the United States Atomic Energy nmission (AEC). Its purpose is to train neers and scientists in the field of reactor ry and technology, in preparation for their employment in this field by the AEC or its contractors.

The Oak Ridge School of Reactor Technology will enroll students of outstanding qualifications who hold, or will receive by September 1951, bachelor's or master's degrees in chemistry, engineering, metallurgy, or physics. A limited number of recent college graduates will be accepted under Category A in the status of student-employees of the Oak Ridge National Laboratory, and will be paid a monthly stipend for a 12-month period, beginning September 1951.

Provision is also made for trainees sponsored by government agencies and industrial organizations connected with or interested in the AEC reactor development program, Category B. Applications for enrollment under this category must be made by the firms or agencies employing the applicants. Such students remain on the payrolls of their home organizations.

Much of the material presented in the curriculum of the Oak Ridge School of Reactor Technology will be classified; hence, all enrollments are contingent upon a personnel security investigation.

Men trained in chemistry, engineering, metallurgy, or physics are much in demand in the reactor development program. It is the purpose of the Oak Ridge School of Reactor Technology to provide engineers and scientists with sufficient background in reactor technology and allied subjects to become effective as research, development, and design personnel.

Further information and application forms may be obtained by writing to the Director, Oak Ridge School of Reactor Technology, Post Office Box P, Oak Ridge, Tenn. Category for which application is requested must be specified. These applications must be filed with the director of the school by March 1, 1951. Announcements of appointments will be made in April 1951.

Critical Shortage of Men In Field of Engineering

The success of America's industrial mobilization program is menaced by shortages of engineers, with the situation held "desperate" in some plants. Critical scarcities exist in the electronic, aviation, power equipment, ordnance, and machine tool industries.

A 4-point program to remedy the situation was recommended to the National Security Resources Board by the Engineering Manpower Commission of the Engineers Joint Council.

1. The registration by Selective Service of every man up to the age of 70 who has a bachelor's degree with a major in one of the critical fields of engineering, or who is enrolled in a program of training leading to a bachelor's or higher degree in one of these fields, or who is employed in one of these fields.
2. The establishment of a National Engineering Personnel Board whose duties shall be to review registrations, to establish criteria for inclusion in a "Reserve," to classify the registrants, and to make selections with critical skills for military, civil defense, and industrial allocation. This Board shall advise the President as to critical needs, allocations, and so forth, and shall administer the Reserve.
3. The Reserve shall be made up of registrants with special skills who have been selected by the National Engineering Personnel Board. The service or allocation of registrants in the Reserve shall be under the direction of National Engineering Personnel Board.
4. The need for technical personnel is so great that the Engineers Joint Council Engineering Manpower Commission believes that every effort should be made to reinforce the technical man power of industry through suitable auxiliary training similar to that of the Engineering, Science, Management War Training Program of the last war.

Infrared Cooking Is Forecast for the Future

Infrared cooking in household ranges is made practical for the first time through the advent of new high-wattage, gold-reflector heat lamps, which employ a new type of heat-resistant glass. The infrared cooking lamps, which are expected to go into commercial production within a short time, were developed by Sylvania Electric Products, Inc., New York, N. Y.

The new lamps are being planned for 1,250 watts, and are intended for either original equipment or conversion units. Advantages claimed for the new lamps are instantaneous heat output, a pleasant ruby-red glow which shows when the lamps are burning, a smooth level surface, easier cleaning, and faster action when small quantities of food are being cooked.

National Bureau of Standards Celebrates Its Semicentennial

The year 1951 marks the 50th anniversary of the National Bureau of Standards (NBS). A large number of the principal scientific and technical organizations of the nation, in recognition of the role of the Bureau in science, have planned meetings in Washington in 1951 to honor the Bureau's semicentennial. Some of the meetings have regularly been held in Washington in the past; most of them were planned for Washington by the societies in view of the Bureau's semicentennial.

Created by Act of Congress on March 3, 1901, NBS is the principal agency of the Federal Government for fundamental research in physics, mathematics, chemistry, and engineering. Thus the Bureau's activities are largely concerned with the physical sciences although the close interrelationships of the major fields of science preclude drawing sharp lines of distinction.

Engineering Societies Personnel Service, Inc. There are many executive and engineering opportunities available for which the Service does not have the personnel to recommend. Registration of men available is very low; therefore, if unemployed or seeking a better opportunity, contact the nearest office of the Engineering Societies Personnel Service, Inc., New York, Chicago, Detroit, or San Francisco.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Waves of all Velocities

To the Editor:

The velocity term contained in Mr. Slepian's equations 3 (Letters to the Editor, *EE, Jan '51, p 93*) is rather all-inclusive for it includes what are commonly referred to as phase and group velocities in addition to the velocity of propagation. The velocity of propagation which is perpendicular to the wave front, or the energy velocity as it is sometimes called, is the one which does not exceed c. Furthermore, the velocity of propagation is independent of the choice of axes. Thus in Dr. Slepian's equation 6, where the x axis has been rotated through an angle, we see that the velocity in the x' direction is now greater than c. However, the velocity in the x' direction is not the velocity of propagation, but rather it is the velocity of a point of constant phase, or phase velocity of the wave. The velocity of propagation is still directed along the x axis, and still equal to c. Indeed, if the x axis were rotated through an angle approaching 90 degrees, the phase velocity would approach infinity, yet the velocity of propagation would remain the same. Hence, the whole discussion is dependent upon the definition of velocity. From this I concede the following:

1. All electromagnetic waves in free space have a velocity of propagation equal to c, the velocity of light in a vacuum.
2. All electromagnetic waves in free space may have phase velocities not equal to c.

If v stands for either 1 or 2, then electromagnetic waves in free space exist with any and all velocities v.

Mr. Slepian's Electrical Essays are a credit to *Electrical Engineering*. I shall look forward to reading more of them.

EDWIN L. PETERSON (Student Member)

(Tulane University, New Orleans, La.)

To the Editor:

Mr. Peterson is quite right in saying that "the whole discussion is dependent upon the definition of velocity." That is the major point of my Letter to the Editor (*EE, Jan '51, p 93*) in which I defined velocity only for such waves as could be put into the mathematical form

$$u=f(x-vt, y, z) \qquad (1)$$

and for such waves, the velocity is defined as having magnitude v, and having the x direction.

There will be waves which cannot be expressed in the form of equation 1, and for such waves the velocity is undefined.

Mr. Peterson seems now to admit that the electromagnetic wave which I used as an example and which was expressed in equation 1 is a proper and satisfactory wave, and that the v in this equation may have any and all values.

But now Mr. Peterson discovers that there are two velocities, a "phase velocity" and a "propagation velocity," but in spite of his having stressed the need for explicit definition of the term velocity, he fails to give a definition of these two velocities. Presumably, he identifies his "phase velocity" with the v of my essay, and permits it to have any and all magnitudes. But how is his "propagation velocity" defined? For the wave equation 1 which presumably has the "phase velocity" v, how is the "propagation velocity" to be determined?

I am very pleased that Mr. Peterson enjoys my essays, and that they inspired this little discussion.

J. SLEPIAN (F '27)

(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Composite System of Units

To the Editor:

Science has long recognized the similarity of behavior between electrical and subatomic particles. Our delay in gaining the necessary knowledge to apply atomic energy to the creation of more enduring things than bombs is largely due to the fact that our electrical technique has thus far been satisfied with results that are only approximately exact. In the subatomic field, the utmost precision is required.

We are now currently using four different systems of base units in the electrical field; practical, electromagnetic, electrostatic, and rationalized meter-kilogram-second units. Tables have been prepared with which to convert results in terms of one system into equivalent expressions in either of the other systems. This situation could be simplified if we had a composite base in which all these units could be expressed.

To make my meaning clear, let us use the subscripts m and s for the electromagnetic and electrostatic units respectively in stating their relation to the corresponding practical units.

With current technique

$$R=R_m(10^{-9})=R_s(9\times10^{11})$$
$$I=I_m(10)=I_s(1/3\times10^{-9})$$
$$E=E_m(10^{-8})=E_s(3\times10^{2})$$
$$R_m/R=10^{9},\ R/R_s=(9\times10^{11}),$$
$$R_m/R_s=(3\times10^{10})^2$$
$$I_m/I=10^{-1},\ I/I_s=(1/3\times10^{-9}),$$
$$I_m/I_s=(1/3\times10^{-10})$$
$$E_m/E=10^{8},\ E/E_s=(3\times10^{2}),$$
$$E_m/E_s=(3\times10^{10})$$

It is obvious that there are at least tw important facts that are inconsistent wi our basic definitions in these values.

(1) abvolts/statvolts $=(3\times10^{10})$
abamperes/statamperes $=1/(3\times10^{1}$
abohms/statohms $=(3\times10^{10})^2$

(2) Converting watts into ergs per secon

$$EI(10^7)=(E\times10^8)(I\times10^{-1})=E_mI_m$$
$$EI(10^7)=(E/3\times10^{-2})(3I\times10^{9})=E_s$$

If we could use the speed of light as ou composite base and define it

1 photosecond $=(3\times10^{10})=$ the distanc in centimeters that each photon moves i one second

we could restate our basic symbols as follow

$$R=R_m(10^{-8})=R_s(3\times10^{2})$$
$$I=I_m(10^{-8})=I_s(3\times10^{2})$$
$$E=E_m(10^{-16})=E_s(3\times10^{2})^2$$
$$R_m/R=10^{8},\ R/R_s=(3\times10^{2}),$$
$$R_m/R_s=(3\times10^{10})$$
$$I_m/I=10^{8},\ I/I_s=(3\times10^{2}),$$
$$I_m/I_s=(3\times10^{10})$$
$$E_m/E=10^{16},\ E/E_s=(3\times10^{2})^2,$$
$$E_m/E_s=(3\times10^{10})^2$$

Converting watts into ergs per second

$$EI(10^7)=(E\times10^{16})(I\times10^{8})(10^{-17})=$$
$$E_mI_m(10^{-17})$$
$$EI(10^7)=(E/9\times10^{-4})(I/3\times10^{-2})$$
$$(27\times10^{13})=E_sI_s(27\times10^{13})$$

$$1=\frac{EI(10^7)}{EI(10^7)}=\left(\frac{E_m}{E_s}\right)\left(\frac{I_m}{I_s}\right)\left(\frac{10^{-17}}{27\times10^{13}}\right)=$$
$$(3\times10^{10})^2(3\times10^{10})\left(\frac{1}{27\times10^{30}}\right)$$

IRVIN J. OSBORN

(1419 West 25th Street, Los Angeles 7, Calif

Social Responsibility in Science

To the Editor:

Dean W. B. Kouwenhoven in his artic "Obligations of the Engineer" (*EE, Dec '5 p 1057*) states that we engineers shoul become aware of our responsibility to other Here are his words: "Since the last cris that threatened our civilization the enginee and scientists have gone right ahead creatin new devices without regard to their effe on our world."

Last year a group of scientists and eng neers deeply concerned at the increasin use of science for destructive ends met an formed the Society for Social Responsibilit in Science. One of the primary aims this group is to create an awareness amon scientists and engineers of the uses to whic their work is put. The society invit inquiry.

NORMAN E. POLSTER (A'4

(Leeds and Northrup Company, Philadelphia 44, P

NEW BOOKS • • • •

The following new books are among those recen received at the Engineering Societies Library. U less otherwise specified, books listed have been p

by the publishers. The Institute assumes no
sibility for statements made in the following
ries, information for which is taken from the
es of the books in question.

ELECTRICAL MEASUREMENTS. By M.
it. Prentice-Hall, Inc., New York, N. Y., 1950.
ges, illustrations, diagrams, charts, tables, $8^3/_4$ by
ches, linen, $7.75. This book is devoted to
d methods and instruments used most frequently
asure electrical phenomena. The principles,
ction, and use of galvanometers, potentiometers,
dges, and other measuring circuits and ancillary
nent are discussed. Two chapters deal with
tic measurements and electric indicating instru-
Introductory material covers such topics as
cal units, experimental procedures, and aids to
tation. Selected references and problems are
d at the end of most of the chapters.

OGRAPHY AND ABSTRACTS ON ELEC-
AL CONTACTS, 1949 Supplement (Technical
ation Number 56-F), prepared by A.S.T.M. Com-
B-4 on Electrical Heating, Resistance, and Re-
Alloys, American Society for Testing Materials,
ace Street, Philadelphia 3, Pa., 1950. 25 pages,
inches, paper, $0.75. This sixth supplement to
ginal bibliography of 1944 provides an approach
latest information on the subject. There are
than 100 items, mainly from 1948 and 1949,
gh a few previously unlisted items from earlier
re included.

CITORS FOR INDUSTRY. By W. C. Bloom-
C. R. Craig, R. M. Partington, and R. C. Wilson.
Wiley and Sons, New York, N. Y.; Chapman and
London, England, 1950. 246 pages, illustrations,
ns, charts, tables, $9^1/_4$ by 6 inches, linen, $4.50.
rest to industrial plant engineers and electricians,
power salesmen, consulting engineers, and
ial power application engineers, this book pro-
practical capacitor application data in tabular
rve form. In most cases, the answer can be
d directly without the solution of the right
or the use of complex algebra. Numerous
es are included illustrating the use of data and,
necessary, the step-by-step procedure for the
of practical problems.

MERCIAL MOTOR TRANSPORTATION.
A. Taff. Richard D. Irwin, Inc., 3201 South
an Avenue, Chicago 16, Ill., 1950. 413 pages,
tions, diagrams, charts, maps, tables, $9^1/_4$ by 6
fabrikoid, $6.65. This book is a broad treat-
of the motor carrier industry which provides
s of transportation and those concerned with
nd bus operations with a comprehensive coverage
field. Part I outlines the scope of the industry
the highway system. Part II covers the property-
g aspects of the industry, Part III is devoted to
er-carrying operations, both local and intercity.
ns and problems are collected at the ends of the
s, and a bibliography is included.

N OF ELECTRICAL APPARATUS. By J.
uhlmann. Third edition. John Wiley and
New York, N. Y.; Chapman and Hall, Ltd.,
, England, 1950. 512 pages, illustrations,
ns, charts, tables, $9^1/_4$ by 6 inches, cloth, $6.50.
al methods are presented for the design of electric
tus, with explanations of the theory, procedure,
nits of design. Changes in this third edition
a revision of design constants and limits, the
of the characteristic curves of electrical sheet
n semilogarithmic paper, the enlargement of the
tables to include new wire insulating materials,
ues of insulation thickness, a review of multiplex
s, and many new methods for determining
al and mechanical characteristics.

ROMAGNETIC WAVES AND RADIATING
MS. By E. C. Jordan. Prentice-Hall, New
N. Y., 1950. 710 pages, diagrams, charts,
$8^3/_4$ by $5^3/_4$ inches, linen, $10.50. Intended
by senior and graduate electrical engineers and
ts, this textbook considers the theory and appli-
of electromagnetic radiation and propagation.
w of fundamental theory is followed by the
tion of more advanced material on electro-
c waves. Transmission lines, wave guides,
ennas are discussed as well as ground-wave and
e propagation. A bibliography and problems
nost of the chapters.

RON MICROSTRUCTURE OF STEEL,
ogress Report, Subcommittee XI on Electron
ructure of Steel, A.S.T.M. Committee E-4 on
Metallography, June, 1950. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. 49 pages, illustrations, 9 by 6 inches, paper, $1.35. Results are presented of studies on the electron microstructure of a eutectoid steel. It contains 47 specially prepared figures consisting of electron micrographs at a magnification of 15,000 and also at 2,500, the latter to compare with light micrographs of the same order of magnification. Detailed descriptive text is provided in connection with these micrographs, as well as details concerning the methods for sample preparation, etching, replica production, and shadowing.

ELEKTRISCHE MASCHINEN. Volume 5, Stromwendermaschinen für ein- und mehrphasigen Wechselstrom Regelsätze. By R. Richter. Springer-Verlag, Berlin, Göttingen, Heidelberg, Germany, 1950. 642 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, linen, 49.50 D.M. This fifth volume of a series on electric machinery provides a detailed treatment of the analysis and design of commutator machines for single and polyphase a-c operation. Calculations, experimental procedures, and control methods are dealt with, with particular attention to control setups using an auxiliary machine for purposes of phase compensation, speed control, or power regulation.

FUNDAMENTALS OF ACOUSTICS. By L. E. Kinsler and A. R. Frey. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1950. 516 pages, diagrams, charts, tables, $8^3/_4$ by $5^3/_4$ inches, linen, $6.00. This book presents the fundamental principles underlying the generation, transmission, and reception of acoustic waves. The first nine chapters provide an analysis of the various types of vibration of solid bodies and of the propagation of sound waves through fluid media. The remaining seven chapters are concerned with a limited number of applications of acoustics. A knowledge of the fundamental principles of mechanics, electricity, and calculus, including partial derivatives, is assumed.

INTRODUCTION TO ELECTRONICS. By J. Yarwood. Chapman and Hall, Ltd., 37 Essex Street, London, W. C. 2, England, 1950. 329 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^3/_4$ inches, cloth, 28s. This book considers the theory and practice of electronics. Following introductory material, the diode and triode, basic associated circuits, amplifiers, and oscillators are discussed. Modulation, detection, and heterodyne techniques are considered. The remaining chapters deal with photoelectric tubes, electron optics, cathode-ray tubes, the electron microscope, and ultrahigh-frequency thermionic tubes.

MODERN AIR-CONDITIONING, HEATING AND VENTILATING. By W. H. Carrier, R. E. Cherne, and W. A. Grant. Second edition. Pitman Publishing Corporation, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 574 pages, illustrations, diagrams, charts, tables, $10^1/_4$ by 7 inches, linen, $10.00. Providing a comprehensive treatment of the whole field, this book applies existing theory to actual practice in the industry. The second edition contains new material in the chapters on estimating, oil-burner applications, panel heating, air cleaning and purification, cooling coils, central conditioning systems, and automatic control. The section on psychrometrics is entirely rewritten, and new data have been added on the subject of comfort. Special topics, such as the economics of heating and conditioning systems and the control of noise and vibration, are also dealt with.

(Les) MOTEURS ÉLECTRIQUES POUR TOUTES APPLICATIONS. By R. Langlois-Berthelot. Éditions-Eyrolles, 61 Boulevard Saint-Germain, Paris (5°), 1950. 264 pages, diagrams, tables, $9^3/_4$ by $6^1/_2$ inches, paper, 980 Frs. The characteristics and operation of electric motors of all types are analyzed, covering both d-c and a-c practice. Particular attention is paid to specialized machines and combinations of electric machinery and to consideration of the electric motor as a unit in such a combination. Brief space is devoted to installation problems in connection with various classes of applications.

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ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

NATIONAL ELECTRONICS CONFERENCE PROCEEDINGS, Volume V, Chicago, Illinois, September 26–28, 1949. National Electronics Conference, 852 East 83rd Street, Chicago 19, Ill., 1950. 581 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $4.00. Some 60 specialized papers are presented in this volume, broadly classified under the following headings: electronic instrumentation; computers; television; antennas; measurements; magnetic devices; research management; theory of communications; vacuum tubes; electromagnetics; supersonics; and audio-frequency. The authors are research and development men from both industrial and academic fields.

PRINCIPLES OF SCIENTIFIC RESEARCH. By P. Freedman. Public Affairs Press, 2153 Florida Avenue, Washington, D. C., 1950. 222 pages, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.25. The history, philosophy, psychology, planning, organization, and usefully applicable techniques of scientific research are discussed for the benefit of those entering, or concerned with, this important field. Examples are given in the last few chapters of the proper approach to a research problem in order to achieve optimum results for a minimum of time and effort expended.

REGISTRIERINSTRUMENTE. By A. Palm. Springer-Verlag, Berlin, Göttingen, Heidelberg, Germany, 1950. 220 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, fabrikoid, 19.50 D.M. This book is a survey of recording instruments used in science and industry. It covers instruments with typical or special properties and those of commercial importance. The first part is devoted to a general consideration of registering or tracing means, methods, and driving mechanisms. Mechanical, electrical, and optical methods of measurement are then discussed with at least one instrument of each type described. The uses of various instruments are also considered.

TELEVISION, Volume V, 1947–1948, 461 pages, TELEVISION, Volume VI, 1949–1950, 422 pages, Edited by A. N. Goldsmith and Associates. RCA Review, Radio Corporation of America, RCA Laboratories Division, Princeton, N. J., August 1950. Illustrations, diagrams, charts, maps, tables, $9^1/_4$ by 6 inches, linen, $2.50 per volume, plus $0.20 postage outside United States. The fifth and sixth volumes of this series cover the years 1947–1948 and 1949–June 1950. Like the previous volumes, they contain papers written by Radio Corporation of America authors which were published in various technical journals and magazines. Each volume is presented in six sections: pickup transmission, reception, color, ultrahigh frequency, and general. Some papers, because of space requirements, are presented in summary form only, whereas other papers are presented as previously published. In volume VI, as an appendix, some 506 technical papers on television and related subjects, written by Radio Corporation of America authors and published from 1929 to June 1950, are listed chronologically.

TELEVISION SERVICING, THEORY AND PRACTICE. By W. H. Buchsbaum. Prentice-Hall, New York, N. Y., 1950. 340 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $5.35. Part I of this practical manual covers the theory of television receivers, starting with the picture tube and progressing to the antenna. The installation practices outlined in Part II conform with the methods employed by a number of well-established service organizations. Part III is a trouble-shooting guide, arranged by symptoms.

ULTRAHIGH FREQUENCY ENGINEERING. By T. L. Martin, Jr. Prentice-Hall, New York, N. Y., 1950. 456 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^3/_4$ inches, linen, $8.00. Intended for senior students majoring in electrical engineering or physics, this book contains a general study of the techniques associated with ultrahigh-frequency systems. It deals with the theory and technique of the component parts that make up complete systems, but not with the functioning of such systems as a whole. Six general areas covered are the generation and synchronization of special wave forms, the amplification of ultrahigh-frequency systems, ultrahigh-frequency transmission systems, circuit elements, oscillators, and the propagation of signals. Mathematics through calculus is assumed.

as well as introductory courses in electron tubes and circuits.

A.S.T.M. STANDARDS ON TEXTILE MATERIALS, prepared by A.S.T.M. Committee D-13; Specifications, Tolerances, Methods of Testing, Definitions and Terms, October, 1950. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. 572 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, paper, $4.50. The 1950 edition of this compilation includes in their latest form 90 specifications, test methods, and tolerances developed by the A.S.T.M. Committee on Textile Materials. A wide range of subject matter is provided relating to asbestos, bast and leaf fibers, cotton, glass textiles, hosiery, rayon and silk, and wool. Appendices include the basic properties of fibers, a psychrometric table, a yarn number conversion table, and several proposed test methods and recommended practices.

CLASSICAL MECHANICS. By H. C. Corben and P. Stehle. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1950. 388 pages, diagrams, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $6.50. The underlying assumptions of classical mechanics are presented in a manner intended to smooth the transition to quantum and relativistic mechanics. It includes the following topics not usually covered in books on mechanics: the problem of central motion; the theory of real linear vector spaces as applied to problems of oscillations, and so forth; the transformation theory of dynamics; Hamiltonian mechanics; Poisson brackets; and so forth. Relativistic mechanics is applied to the motion of ions in high energy accelerators.

ELEKTRISCHE HEIZEINRICHTUNGEN FÜR INDUSTRIE UND GEWERBE. By W. Schulz. Third edition. W. Schulz Selbstverlag, Kurhessenstrasse 162, Frankfurt A. M.-Ginnheim, Germany, 1950. 163 pages, illustrations, diagrams, charts, tables, $8^1/_4$ by 6 inches, paper, 6.40 D.M. Electric heating equipment for a wide variety of industrial purposes is described briefly, covering a range from small resistance elements to large drying ovens. Condensed information on fundamentals, calculations, and control devices also is included.

ENCYCLOPEDIA ON CATHODE-RAY OSCILLOSCOPES AND THEIR USES. By J. F. Rider and S. D. Uslan. John F. Rider, Publisher, 480 Canal Street, New York 13, N. Y., 1950. 982 pages, illustrations, diagrams, charts, tables, 11 by $8^1/_2$ inches, linen, $9.00. This book covers the theory and uses of all types of cathode-ray oscilloscopes and synchroscopes manufactured from 1940 to 1950. It is divided roughly into four categories: the first dealing with theory and operation; the second, with applications; the third, with commercial oscilloscopes and related equipment; and the last is a compilation of 1,600 complex wave form patterns. Three appendices on the characteristics of cathode-ray tubes, Radio Manufacturers Association cathode-ray bases, and photography and a bibliography complete the book.

INTRODUCTION TO ELECTRON OPTICS. By V. E. Cosslett. Second edition. Oxford University Press, New York, N. Y.; and Clarendon Press, Oxford, England, 1950. 293 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by 6 inches, cloth, $6.00. This book provides a connected treatment of the production, propagation, and focusing of electron and ion beams. Its main emphasis is on the theory of electron lenses and their application in cathode-ray tubes and electron microscopes. Attention also is paid to other devices employing electron beams in radio and atomic physics. In the second edition a set of numerical examples is added to illustrate the theoretical work of the first five chapters. New material is collected in a series of notes at the end of the book.

OPERATIONAL CALCULUS BASED ON THE TWO-SIDED LAPLACE INTEGRAL. By B. Van der Pol and H. Bremmer. Cambridge University Press, American Branch, New York, N. Y., 1950. 415 pages, diagrams, charts, tables, 10 by $6^1/_4$ inches, linen, $10.00. Written for engineers and mathematicians, this book applies operational calculus in its modern form to mathematics, physics, and technical problems. It provides the basic principles, ideas, and theorems as well as many worked-out problems. Its purely mathematical treatment is more advanced than is usually found in books devoted to practical applications. The subject is treated by means of the bilateral or 2-sided Laplace integral rather than by the usual 1-sided Laplace integral. Rules, relations, and the various kinds of functions treated are presented in condensed form in an appendix.

PHYSICS, FUNDAMENTAL PRINCIPLES FOR STUDENTS OF SCIENCE AND ENGINEERING. 2 Volumes. By G. Shortley and D. Williams. Prentice-Hall, New York, N. Y., 1950. 1,271 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, Volume 1, $6.00; Volume 2, $7.35. Written as a text for sophomore engineering students, this 2-volume set provides a rigorous introductory treatment of the fundamental principles of physics. Mechanics and heat are considered in Volume I, and sound, light, electricity, magnetism, and modern physics in Volume II. Prerequisites are courses in chemistry and high-school physics and mathematics. A corequisite course in calculus also is assumed. The gravitational British-Engineering system and the absolute meter-kilogram-second system of units are used.

PRINCIPLES OF ELECTROMAGNETISM. By E. B. Moullin. Second edition. Oxford University Press, New York, N. Y.; Clarendon Press, Oxford, England, 1950. 311 pages, diagrams, charts, tables, $9^1/_2$ by 6 inches, cloth, $6.00. Written to provide a basic text for the author's teaching work, this book develops the subject as an immediate preliminary to subsequent study of electric machinery and communications methods. The subject matter is divided into the following major sections: elements of magnetism; second law of electrodynamics; iron in a magnetic field; and two groups of special electromagnetic equations. The new edition has an appendix enlarging on the skin effect of alternating currents.

PRODUCTION PLANNING AND CONTROL. By T. M. Landy. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 436 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, linen, $5.50. Part I of this text deals with the problem of installing and operating a modern production planning and control system. Part II, the largest section, is a declaration of the principles and laws governing the subject, as well as a detailed analysis of the various functions. In Part III, supplementary but equally important functions are analyzed and illustrated with case studies. An appendix contains a list of abbreviations and symbols.

SIMILITUDE IN ENGINEERING. By G. Murphy. Ronald Press Company, New York, N. Y., 1950. 302 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $7.00. Written on the graduate-engineering level, this book is an organized presentation of the problems of model design and the interpretation of model tests. In the first part, the concepts and techniques of dimensional analysis are developed and utilized to develop the principles of design of models. In the second, a rational approach to the design of distorted models and results obtained from them are presented. The third and last is devoted to a study of analogies from the standpoint of model-prototype relationships.

WORLD GEOGRAPHY OF PETROLEUM (American Geographical Society Special Publication Number 31). Edited by W. E. Pratt and D. Good, published for the American Geographical Society by Princeton University Press, Princeton, New Jersey, 1950. 464 pages, illustrations, diagrams, charts, maps, tables, 10 by $6^3/_4$ inches, linen, $7.50. Based on information provided by a group of expert petroleum geologists and administrators, this book is a comprehensive discussion of the world oil situation. Part I is devoted to the discovery of oil-bearing areas. Part II describes the organization of the petroleum industry including development, production, storage, transportation, refining, and distribution. The main section of the book, Part III, considers all the great productive regions with the problems induced by their geology, topography, climate, vegetation, accessibility, population, culture, and industrial development. In Part IV the central theme is the geography of petroleum use. Fifty specially prepared maps, 11 diagrams, and 98 photographs are included to supplement the text.

PAMPHLETS ● ● ● ● ●

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

International Electrotechnical Vocabulary. This 1950 reprint contains nearly 2,000 scientific and technical terms, divided into 14 groups and some 100 sections. Complete
definitions are given in French and En
with the corresponding titles additio
listed in German, Italian, Spanish,
Esperanto. Available from the Ame
Standards Association, 70 East 45th S
New York 17, N. Y., at $4.50 per copy

**Related Instruction—A Key to Appre
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manpower demands make imperativ
surance of a continuing supply of s
workers for the construction industry.
responsibilities of interested group
education, industry, labor, and govern
are discussed. Particularly emphasiz
the role of vocational education in
related technical and supplemental ins
tion of apprentices. Available at 10
a copy from the Chamber of Comm
Construction and Civic Development
partment, Washington 6, D. C.

Research Is Learning. A comprehe
definition of the role of research in engi
ing education, compiled by representa
of 83 engineering schools. Also incl
are 12 brief summaries of universities
search activities which are designe
provide specific examples of the more ge
statements. Illustrated. Copies are
able without cost on request to the Secr
of the Engineering College Research C
cil, Room 7-204, 77 Massachusetts Av
Cambridge 39, Mass.

**Report on Standard Samples for Spe
chemical Analysis.** Compilation of
and sources of standards for the inform
of analysts. There are listed in the for
extensive tables and data available stan
samples on: iron and steel; aluminum
its alloys; magnesium and its alloys;
lead, and tin alloys; and copper alloys.
pages. Available from American So
for Testing Materials, 1916 Race S
Philadelphia 3, Pa., at $1.25 per copy.

Bibliography of Technical Reports
review of research in the incande
brazing of copper bus bars is feat
Also included are items on the deterior
of cast-iron pipe; offshore petroleum o
tions; pectin in dehydrated foods; cons
pressure combustion; structural guide
the development of synthetic lubric
standing-wave detectors; moisture ab
tion of tropical woods; and rescue
survival equipment. There are 259
nical reports from federal, foreign, and
reports. Available at 50 cents a copy
the United States Department of Comm
Washington, D. C.

**Supplement—Steam-Electric Plant
struction Cost and Annual Produ
Expenses—1937–1947.** Presents cost
for 243 plants located in 40 states.
dividual data sheets on each of the
lists information on installed gener
capacity, peak demand, cost of plant,
duction expenses, and quantity and c
fuels used. The supplement presents
on 26 new plants not included in eithe
original 1938–47 publication or in the
supplement. The supplement may b
tained for 50 cents from the Public
Sections, Federal Power Commi
Washington 25, D. C.

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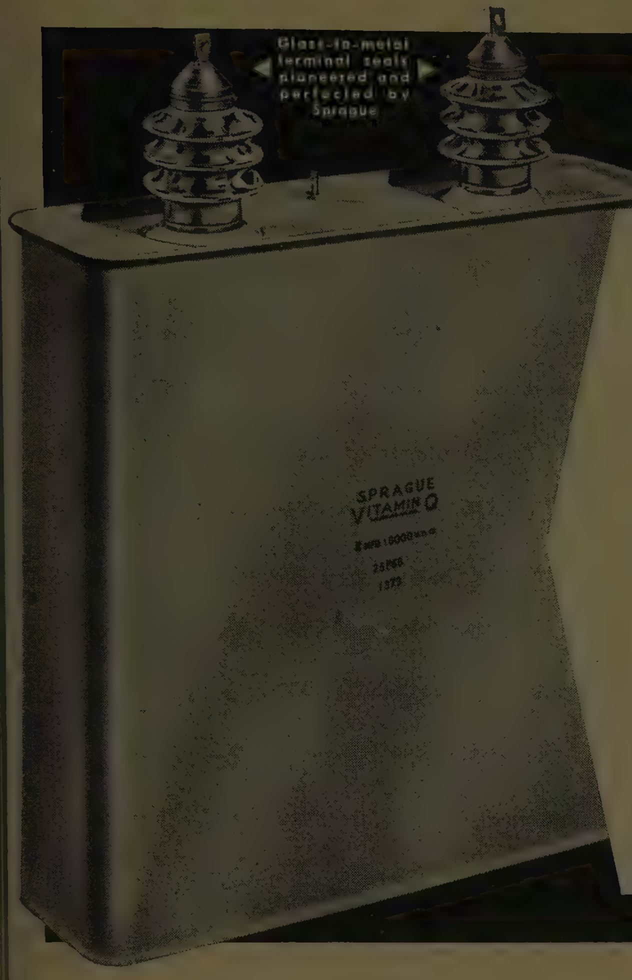
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10.0	8000	13½	4¼	13⅛	2¼	25P54
12.0	8000	13½	5¼	12¼	2¼	25P55
1.0	10000	8⅛	4⅛	5½	3 11/16	25P56
2.0	10000	8⅛	4⅛	8½	3 11/16	25P57
4.0	10000	13½	4¼	9¼	3 11/16	25P58
6.0	10000	13½	4¼	13⅛	3 11/16	25P59
8.0	10000	13½	5¼	12⅞	3 11/16	25P60
1.0	12500	8⅛	4⅛	7½	3 11/16	25P61
2.0	12500	8⅛	4⅛	12¼	3 11/16	25P62
4.0	12500	13½	5¼	11½	3 11/16	25P63
5.0	12500	13½	5¼	13¾	3 11/16	25P64
1.0	16000	8⅛	4⅛	10½	4 11/16	25P65
2.0	16000	13½	4¼	12¼	4 11/16	25P66
3.0	16000	13½	5¼	13¾	4 11/16	25P67
1.0	20000	13½	4¼	11	4 11/16	25P68
1.5	20000	13½	5¼	12¼	4 11/16	25P69

†Capacitors with voltage ratings above 10 KV are recommended for upright mounting only. For mounting in other positions, please supply complete application data for recommendation by Sprague engineers.

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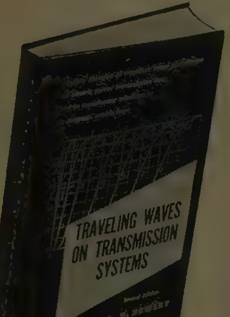

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Data on attenuation and distortion of waves

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A revised approach to switching surges and recovery voltages of circuit breakers

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INDUSTRIAL NOTES . . . .

Standard Coil Products Company Acquires Kollsman Division. Standard Coil Products Company, Inc., of Los Angeles, Calif., and Chicago, Ill., has purchased from the Square D Company the latter's Kollsman Division, located in Elmhurst, L. I., N. Y. The Kollsman Division, which manufactures aircraft instruments, will continue to operate with the same personnel in the same plants. Victor E. Carbonara, who has headed this division for over ten years, will be its President. The purchase price was stated to be around $5,000,000.

RCA Elections. Walter A. Buck, a former Rear Admiral in the United States Navy, and since 1949 Operating Vice-President of the RCA Victor Division, has been elected to the Board of Directors of the Radio Corporation of America (RCA). Mr. Buck succeeds Edward J. Nally, who has retired. RCA has also announced the appointment of David S. Rau as Assistant Vice-President and chief engineer of RCA Communications, Inc.

Measurements Corporation Moves. The Measurements Corporation, Boonton, N. J., has moved all their manufacturing departments, laboratories, and offices into their new Intervale Road plant, also in Boonton.

Sylvania Electric Appointments. Sylvania Electric Products, Inc., has made three new appointments in their Radio and Television Division: Howard Riordan, formerly Vice-President and controller of the Colonial Radio Corporation (once a subsidiary of Sylvania), has been appointed general manufacturing manager; Bernard O. Holsinger has been named assistant general sales manager; and Hulbert C. Tittle has been made assistant chief engineer.

Rockbestos Products Promotions. Two major appointments were announced by the Rockbestos Products Corporation: Charles A. Berlepsch was named to the newly created post of Director of Purchases, and Raymond B. Miniter was named as purchasing agent.

Minneapolis-Honeywell Buys Thomas M. Royal Plant; Appointments. The Brown Instrument Division of the Minneapolis-Honeywell Regulator Company is expanding its industrial production and operating facilities in Philadelphia by the purchase of the Thomas M. Royal plant and about 60,000 square feet of undeveloped property in addition and adjacent to the new site. The Minneapolis-Honeywell Regulator Company also has announced the following appointments: Eldon E. Fox has been named advertising manager; R. M. Locke, assistant sales manager, wholesale division; J. C. Dorsey, sales manager, manufacturers' division, mid-Atlantic region, Philadelphia; H. S. Gray, sales manager, wholesale division, midwest region, Chicago; W. E. Dobie, sales manager, wholesale division, eastern region, New York City; and R. G. Hayes, sales manager, wholesale division, mid-Atlantic region, Philadelphia.

Philco Subsidiary to Build New Plant in Maryland. The Lansdale Tube Company, Lansdale, Pa., a subsidiary of the Philco Corporation, has purchased a site at Frederick, Md., for a new electronic tube plant, which is scheduled to be in operation before the end of 1951.

I-T-E Names Arizona Representative. The I-T-E Circuit Breaker Company, Philadelphia, Pa., has named the Central Station Engineering Company, Tucson, Ariz., as its Arizona representative.

Thompson Products Enters Electronics Field. Thompson Products, Inc., manufacturers of parts for the automotive and aircraft industries, is entering the electronics field via an exclusive license agreement with Designers for Industry, Inc. By this agreement, the company has taken over the development, manufacture, sales, and service of coaxial switches. An electronics division is being established at the Thompson Cleveland main plant under the direction of Len W. Reeves, Vice-President. The engineering program is being guided by A. L. Pomeroy, Director of Staff Development.

Allis-Chalmers Forms Chicago Warehouse Sales Unit. The Allis-Chalmers Manufacturing Company has set up a new section in their Chicago district office to handle the sale of small apparatus including motors, controls, drives, and pumps. George A. Wampler has been named manager.

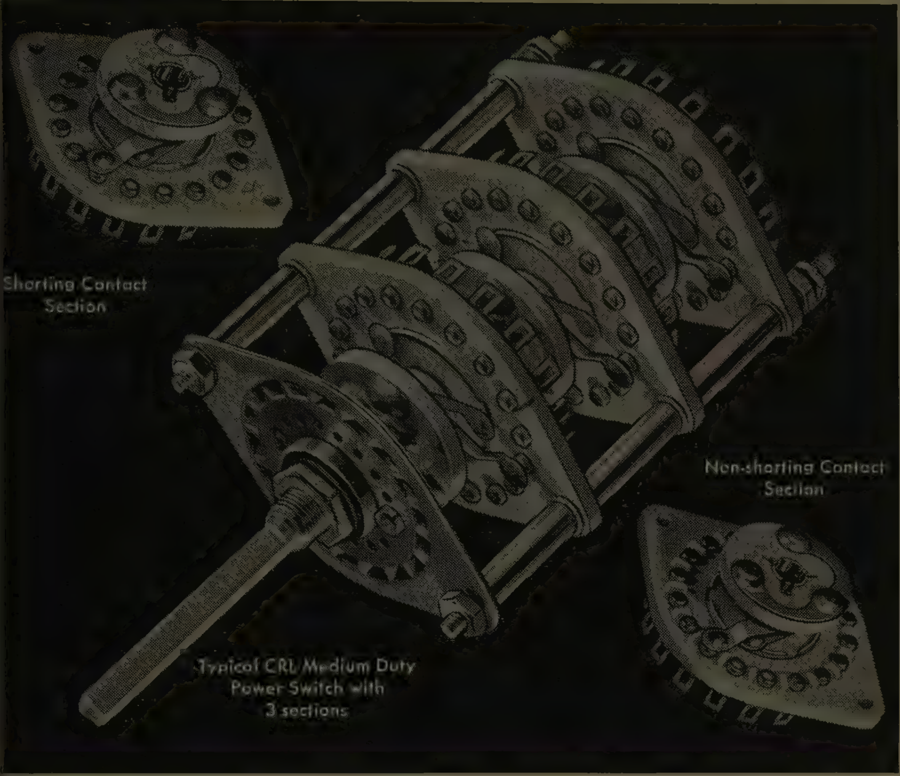
G-E Appointments. The General Electric Company has announced the appointments of Leon C. Swager as wage administrator for the company's Fort Wayne works; Robert C. Walton as assistant to the manager of marketing of the General Electric Appliance and Merchandise Department; and J. P. Evans as assistant manager of appliance sales in the company's North Central District.

H. L. Cramer Appointed to New Westinghouse Sales Post. The creation of a new sales department—the Agency and Construction Department—and appointment of Harold L. Cramer as its manager, has been announced by the Westinghouse Electric Corporation.

National Carbon Plans Major Electrode Plant Expansion. The National Carbon Division of the Union Carbide and Carbon Corporation has announced plans for a further major addition to its present carbon electrode plant at Columbia,

(*Continued on page 22A*)

CENTRALAB MAKES CUSTOM BUILT MEDIUM-DUTY POWER SWITCHES



Shorting Contact Section

Non-shorting Contact Section

Typical CRL Medium Duty Power Switch with 3 sections

ONLY CENTRALAB MEDIUM-DUTY POWER SWITCHES GIVE YOU WIDE CHOICE OF STANDARD OR CUSTOM COMBINATIONS

STANDARD MEDIUM DUTY SWITCH SIZES

Part No. Shorting	Part No. Non-Shorting	Total Poles	Positions	Total Sections	Poles per Section
JV9000	JV9001	1	2-17	1	1
JV9002	JV9003	3	2- 5	1	3
JV9004	JV9005	2	2-17	2	1
JV9006	JV9007	6	2- 5	2	3
JV9008	JV9009	3	2-17	3	1
JV9010	JV9011	9	2- 5	3	3
JV9012	JV9013	4	2-17	4	1
JV9014	JV9015	12	2- 5	4	3
JV9016	JV9017	5	2-17	5	1
JV9018	JV9019	15	2- 5	5	3
JV9020	JV9021	6	2-17	6	1

Furnished with adjustable stop to limit rotation to desired number of positions

Centralab's Medium-Duty Power Switches are made to meet your individual needs — 1, 2 or 3 poles — 18 contacts per section — up to 20 sections per shaft. Contacts and collector rings are of coin silver, mounted on Grade L5 Steatite . . . compounded and produced right in our own plant.

Switches are designed for R.F. or 7½ amp., 110-115 V. application. The combination of rugged construction — coin silver contacts plus the high insulation resistance of Grade L5 Steatite means long-term, trouble free performance.

For top-performing, medium-duty power switches, in standard or custom models, ask about Centralab's famous "torture-tested" switch line. Our engineers will be glad to assist you.

Centralab CRL ®

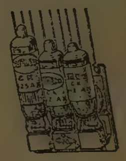
vision of GLOBE-UNION INC. • Milwaukee

CHOOSE FROM THE NEW CENTRALAB LINE OF ELECTRONIC COMPONENT PARTS

CERAMIC CAPACITORS

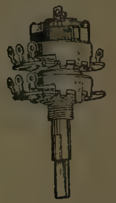
Centralab Ceramic capacitors offer every value you need for modern electronic equipment. You can get tiny disc-types (smaller than a dime) for by-pass or coupling applications. You can get temperature compensating or by-pass coupling tubulars . . . and you can get true high voltage (10, 20, 30 KV) ceramics that are the accepted standard of the TV industry.

PRINTED ELECTRONIC CIRCUITS



P.E.C.'s are a startling development for saving soldered connections, space, weight and man-power. Used where small size is prime essential.

VARIABLE RESISTORS



Centralab makes a complete line of variable resistors (controls) for nearly all low-wattage requirements.

SPECIAL EQUIPMENT

Centralab offers wide variety in special capacitors, tubular trimmers, switches, Steatite and other ceramic components. Write direct stating your problem.

CENTRALAB Div. of Globe-Union Inc.
927 East Keefe Avenue
Milwaukee 1, Wisconsin

FREE
Mail this coupon for your copy of Centralab Switch Catalog No. 722. Check below for other literature wanted.

..................Hi-Voltage Ceramic Capacitors
..................Disc-Type Ceramic Capacitors
..................Tubular Ceramic Capacitors
..................Printed Electronic Circuits
..................Variable Resistors

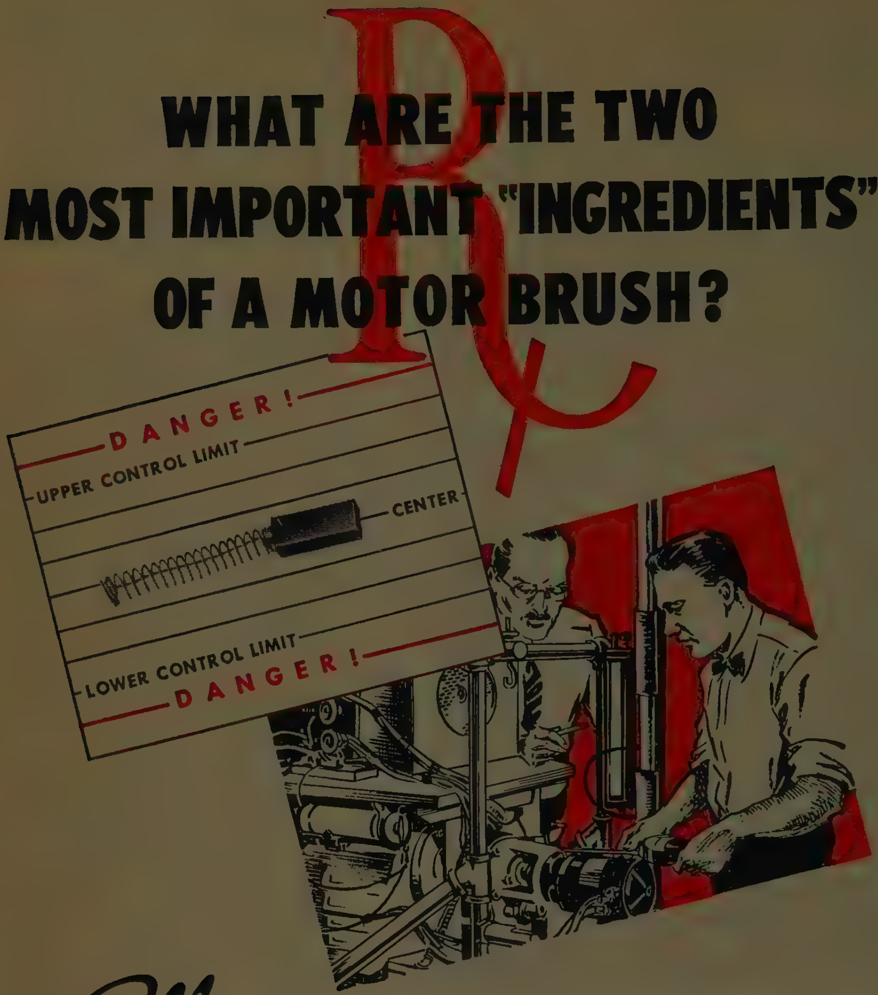
Name..

Company Name..

Address...

City..............................Zone.........State...............

WHAT ARE THE TWO MOST IMPORTANT "INGREDIENTS" OF A MOTOR BRUSH?



Most small motor brushes are made from the same basic materials, on the same type of equipment, under much the same conditions. What then, makes one line of brushes so outstandingly superior to another for a given application?

Here at Stackpole, we're convinced there are two chief factors involved: (1) Laboratory Engineering by brush experts who produce a brush formula for the specific product involved under actual operating conditions and, (2) Statistical Quality Control that covers brush processing from the base materials through every step of manufacture. Characteristics are carefully controlled, maximum uniformity assured.

Long experience proves that, backed by these two basic Stackpole ingredients, almost any small motor brush performance can be materially improved.

● *Stackpole brushes are sold only to makers of original equipment* ●

STACKPOLE

Write today for your copy of this helpful 44-page Brush Users' Guide

STACKPOLE CARBON CO.
ST. MARYS, PA.

(*Continued from page 16A*)

Tenn. Production from the new facilities is expected to begin by the middle part of 1951, and when completed by early 1952 will add many million pounds of graphite production annually, as well as materially increase the production of carbon electrodes. As a further part of their program to supply carbon electrodes to meet the growing demand for electrical steel, improvements are also being made at the corporation's electrode plants at Clarksburg, W. Va., and Niagara Falls, N. Y.

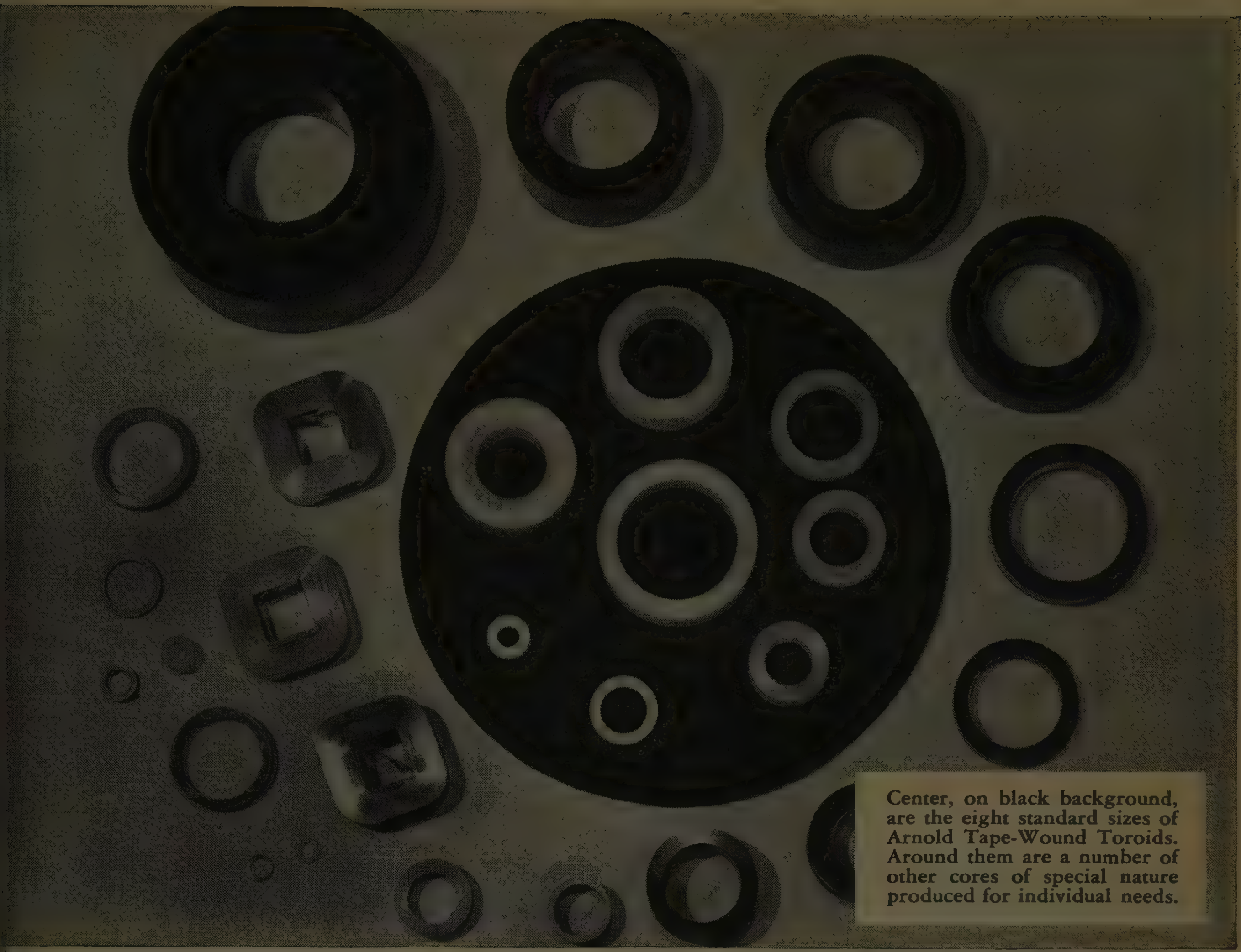
Philco Appointments. Frederick J. Willard has been appointed Vice-President of sales, F. Leroy Sherman Vice-President of foreign operations, and Radcliffe L. Romeyn has been made Vice-President and executive assistant to the President of the Philco International Corporation. The Philco Corporation has also announced the appointment of Bert Cole as district sales representative for the New York—Newark area.

NEW PRODUCTS • •

Static Magnetic Memory. Developed by the Harvard Computation Laboratory and manufactured by the Alden Products Company, 117 North Main Street, Brockton, Mass., the Static Magnetic Memory is a new device for recording and storing information in digital calculating machinery. Based upon the discovery of a ferromagnetic alloy having a fairly rectangular hysteresis loop of low coercive force, the Static Magnetic Memory operates essentially as a magnetic trigger pair which requires no vacuum tubes to maintain position. Permanent information storage of this device is comparable to magnetic drum storage, but independent of mechanical movement. A variable information handling rate ranges from zero to 30,000 cycles per second with probable increases in the future limit, and pulse information storage without power. Any further information may be obtained from the Alden Products Company.

Copyflex. The Charles Bruning Company has developed a new type of offic copying machine which needs no inks, tray developing, special lighting, stencils, o negatives. Called the "BW Copyflex," this machine uses the BW Diazo process which is based on paper coated with a analine dye. Within the machine thi dye coating is bleached by actinic ligh rays, except where the record or documen to be copied has markings, such as typing printing, or line drawing. These markings prevent light from bleaching the dye and a sharp, clean, black line is formed reproducing exactly the markings on th original copy. If the original document i marked on both sides or is on opaque stock the machine copies it onto BW reflex fil and the film then is used to make as man copies as are desired. Both sides of a

(*Continued on page 30A*)



Center, on black background, are the eight standard sizes of Arnold Tape-Wound Toroids. Around them are a number of other cores of special nature produced for individual needs.

ARNOLD TAPE-WOUND TOROIDAL CORES

of DELTAMAX
4-79 MO-PERMALLOY
SUPERMALLOY*

APPLICATIONS

MAGNETIC AMPLIFIERS
PULSE TRANSFORMERS
NON-LINEAR RETARD COILS and TRANSFORMERS
PEAKING STRIPS, and many other specialized applications.

RANGE OF SIZES

Arnold Tape-Wound Toroids are available in eight sizes of standard cores—all furnished encased in molded nylon containers, and ranging in size from ½″ to 2½″ I.D., ¾″ to 3″ O.D., and ⅛″ to ½″ high.

RANGE OF TYPES

These standard core sizes are available in each of the three magnetic materials named, made from either .004″, .002″ or .001″ tape, as required.

In addition to the standard toroids described at left, Arnold Tape-Wound Cores are available in special sizes manufactured to meet your requirements—toroidal, rectangular or square. Toroidal cores are supplied in protective cases.

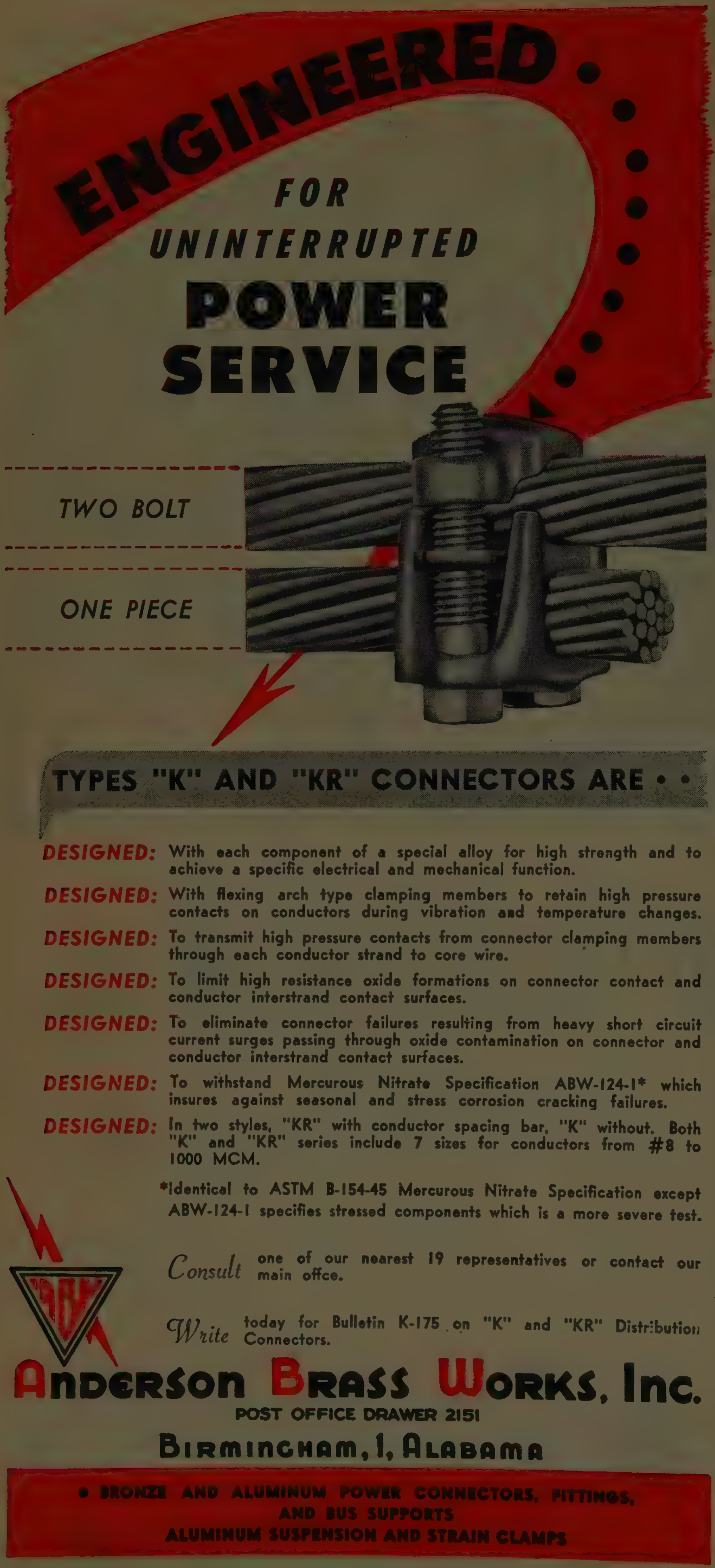
**Manufactured under licensing arrangements with Western Electric Company.*

W&D 3182

THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

General Office & Plant: Marengo, Illinois


ENGINEERED FOR UNINTERRUPTED POWER SERVICE

TWO BOLT

ONE PIECE

TYPES "K" AND "KR" CONNECTORS ARE • •

DESIGNED: With each component of a special alloy for high strength and to achieve a specific electrical and mechanical function.

DESIGNED: With flexing arch type clamping members to retain high pressure contacts on conductors during vibration and temperature changes.

DESIGNED: To transmit high pressure contacts from connector clamping members through each conductor strand to core wire.

DESIGNED: To limit high resistance oxide formations on connector contact and conductor interstrand contact surfaces.

DESIGNED: To eliminate connector failures resulting from heavy short circuit current surges passing through oxide contamination on connector and conductor interstrand contact surfaces.

DESIGNED: To withstand Mercurous Nitrate Specification ABW-124-1* which insures against seasonal and stress corrosion cracking failures.

DESIGNED: In two styles, "KR" with conductor spacing bar, "K" without. Both "K" and "KR" series include 7 sizes for conductors from #8 to 1000 MCM.

*Identical to ASTM B-154-45 Mercurous Nitrate Specification except ABW-124-1 specifies stressed components which is a more severe test.

Consult one of our nearest 19 representatives or contact our main offce.

Write today for Bulletin K-175 on "K" and "KR" Distribution Connectors.

ANDERSON BRASS WORKS, Inc.
POST OFFICE DRAWER 2151
BIRMINGHAM, 1, ALABAMA

• BRONZE AND ALUMINUM POWER CONNECTORS, FITTINGS, AND BUS SUPPORTS
ALUMINUM SUSPENSION AND STRAIN CLAMPS

(*Continued from page 22A*)

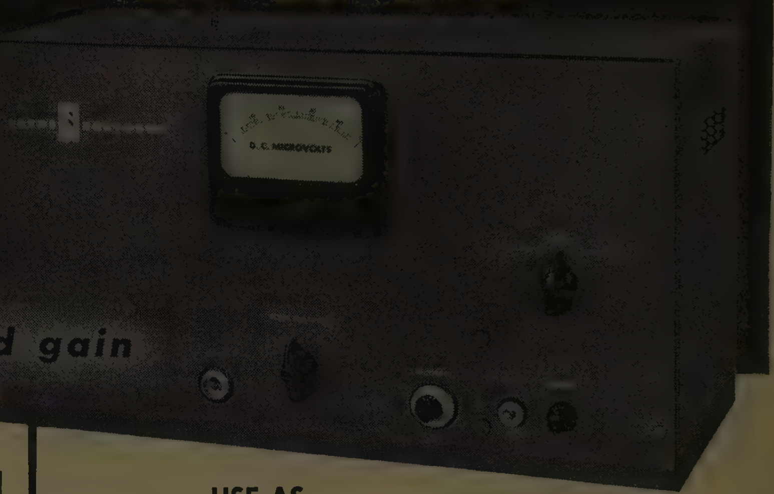
original can be copied, and all exposing and developing of the film is done within and by the machine. The Copyflex needs no installation—it can be placed anywhere and merely connected to the ordinary office electric light line carrying standard 60-cycle 110-volt alternating current. Additional information may be obtained from the Charles Bruning Company, Inc., 100 Reade Street, New York 13, N. Y., upon written request.

Vibrator Converters for Railroad Application. The Cornell-Dubilier Electric Corporation has introduced two new vibrator converters for railroad application. Both incorporate a self-servicing enroute feature, which is made possible by automatic switch-over to a stand-by vibrator when the service vibrator reaches the end of its useful life. Thus uninterrupted service is insured on the longest trip, with no attention required from the train crew. A warning light signal indicates need for vibrator replacement on routine maintenance check-ups. Model *3248* has been designed for a 32-volt d-c input and delivers 115-volt 60-cycle alternating current, with a maximum power output of 375 voltamperes. This unit is filtered for a broadcast band and is shock-mounted for passenger car service. Model *3212A* has been designed specifically for operating radio communications equipment in cabooses where 12 volts is the available source of power. It delivers 115-volt 60-cycle alternating current, with a power output of 175 voltamperes maximum. For complete technical data, write to the Cornell-Dubilier Electric Corporation, Indianapolis Division, 2900 Columbia Avenue, Indianapolis, Ind.

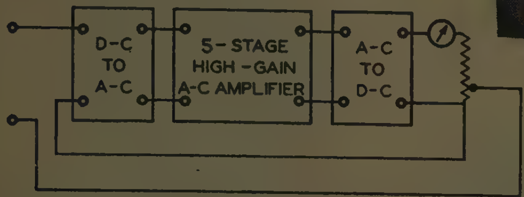
The Microsyn. A new type of regulating device—the microsyn—which provides regulation in infinitesimal steps, has been announced by the Westinghouse Electric Corporation, 306 Fourth Avenue, Pittsburgh 30, Pa. The basic idea for this instrument originated in the Instrumentation Laboratories of the Massachusetts Institute of Technology. The microsyn can do three kinds of things: it can produce a voltage proportional to turning a rotor over a range of ±10 degrees, with a sensitivity of 20 seconds; it can produce a torque that is linear with the square of a signal current; and it can act as an elastic restraint generator, producing a torque proportional to the product of the square of a current and the angular displacement. The microsyn consists of a moving element in a 4-pole field. The magnetic structure is of Hipernik, specially processed to give a hysteresis loop of small area and a permeability of 100,000 with 0.03 oersted coercive force. This specially processed Hipernik alloy has extremely consistent characteristics. In order to achieve consistent and precise results, the microsyn must have very accurate dimensional control—all ground surfaces must be accurate to 0.1 mil. Further details may be obtained from Westinghouse Electric Corporation.

(*Continued on page 32A*)

For low-level d-c measurements Use these new, triple-purpose D-C INDICATING AMPLIFIERS



stabilized for zero and gain



Voltage-balance feedback (above) and current-balance feedback stabilize gain . . . provide virtual null balance.

SPECIFICATIONS

MICROVOLT UNIT Catalog No. 9835	MICRO-MICRO-AMPERE UNIT Catalog No. 9836
FULL SCALE RANGES WITH BUILT-IN 4″ METERS	
0 to 50 or —25 to +25 Microvolts; scale multipliers: 1,2,4,10, 20,40	0 to 1000 or —500 to +500 Micro-Micro-amps; scale multipliers: 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000
ACCURACY	
Of amplifier: ±0.4% of reading ±0.5 Microvolt; Of meter: ±1%	Of amplifier: ±0.5 to 0.8%* of reading ±20 Micro-Micro-amps; Of meter; ±1%
STABILITY	
Zero and Gain stabilized automatically. No trimmer controls required.	
***SOURCE RESISTANCE**	
Up to 10,000 ohms.	0.1 megohm or more.
RESPONSE TIME	
2 to 3* sec.	2 to 3* sec.
OUTPUT	
For full scale input on any range: 10 millivolts at output impedance of 500 ohms for null recorder; 1 volt for 20,000-ohm external meter.	

Front panel fits standard 19″ relay rack.

*Accuracy and Response Time depend on Source Resistance.

USE AS

- DIRECT-READING MICROVOLTMETER OR MICRO-MICROAMMETER
- RECORDER PREAMPLIFIER
- NULL DETECTOR

These new instruments are not only D-C Indicating Amplifiers but are stable, accurate measuring instruments as well. You can use them in measurements with thermocouples, strain gages, bolometers . . . bridge and potentiometer circuits . . . ionization, leakage, and phototube currents . . . almost any measurement of extremely small direct current or voltage.

Through a combination of a-c amplification and unique balanced feedback network, zero and gain stability are designed right into the instrument. Trimmer controls are designed out—eliminated.

Actually *three* instruments in one, these amplifiers can be used as—

Direct-reading instruments . . . At the turn of a scale-multiplier knob, you simply select the range in which you want to work.

Recorder preamplifiers . . . with broad flexibility. For instance, one or two degrees of temperature difference can be spread across an entire Speedomax recorder scale.

Null detectors . . . more sensitive than most reflecting galvanometers, yet with full scale response time of only 2 to 3 seconds. Leveling is unnecessary. There's no worry about shock or vibration. At the turn of a range knob, you have available a wide choice of sensitivities. External shunts are not required. And when using non-linear response, not only does the instrument stay on scale at extreme unbalance; sensitivity increases automatically as the null point is approached. For details, write to Leeds & Northrup Co., 4962 Stenton Ave., Phila. 44, Pa.

Jrl ad EM9-51(1)

MEASURING INSTRUMENTS TELEMETERS AUTOMATIC CONTROLS · HEAT-TREATING FURNACES
LEEDS & NORTHRUP CO.

DESIGN — Engineers have found that time is saved by using Standard's design service whenever they specify transformers for use in special projects. Long design experience on transformers for all needs, including power, distribution, metering and testing, is at your service.

MANUFACTURING — Standard's methods are set up for quality production . . . many functions ordinarily left to mass methods are performed by specialists and skilled mechanics who do custom work. Specifications established by ASA are met or exceeded. Job proved products are your assurance of complete satisfaction.

● Get acquainted with The Standard Transformer Company. Be sure Standard's booklet CL-50-EE is in your files.

OFFICES IN PRINCIPAL CITIES

THE Standard
TRADE MARK ®
TRANSFORMER CO.
WARREN, OHIO
(Exclusively transformer designers and manufacturers)

TRANSFORMERS FOR EVERY APPLICATION

Liquid filled (sizes up to 10,000 KVA and 72 KV inc.)

Instrument transformers (for use on circuits up to 72,000 volts, inc.)

Dry type (up to 1000 KVA and max. voltage ratings of 4800)

Control transformers (compound filled or open type)

(*Continued from page 30A*)

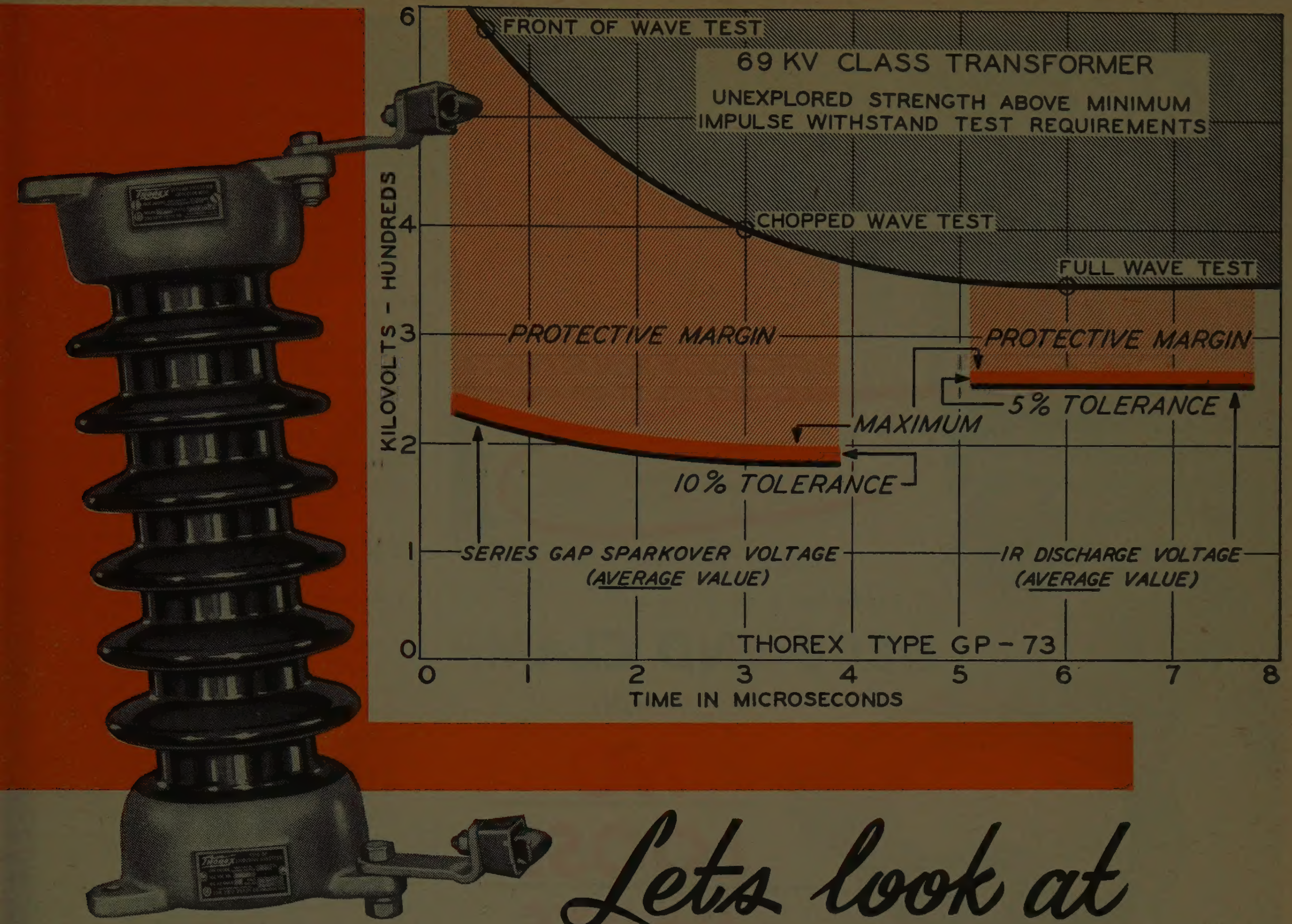
Fogheds. A water fog-producing device developed for use in fixed piping systems for the fire protection of oil-filled electric transformers, switches, and so forth, has been introduced by Fog Nozzle International, a division of the Akron Brass Manufacturing Company, Inc., Wooster, Ohio. Because water fog is a nonconductor of electricity, the Fogheds may be installed relatively close to the hazard involved; therefore, the proper application of the water fog to the hazard under exposed conditions out-of-doors is assured. As transformer oils are of very high flash point and only the extreme temperature of an electric arc will cause vaporization of this oil, it follows that when this material is cooled below its vaporization point, the fire is extinguished. Additional information on Fogheds may be obtained from the company.

Nonconsumable Electrode for Welding. Thoriated tungsten is now available as a nonconsumable electrode (called Thor-Tung) for d-c straight polarity welding. Thor-Tung, because it operates much cooler than standard tungsten electrodes, permits the use of higher currents on given size electrodes and does not become molten, so that consumption is negligible and contamination resulting from accidental or deliberate touching is eliminated. Thor-Tung may also be pointed to permit continued operation at very low current. Further details are available from Air Reduction, 60 East 42nd Street, New York 17, N. Y.

Thyratron Tube. A new gas thyratron tube which can operate at maximum ratings over a wide temperature range has been announced by the General Electric Tube Divisions. The new tube, designed mainly for general control-circuit applications, has a quick-heating cathode which takes only a minute to reach operating temperature. Designated the *GL-5855*, the 3-electrode inert-gas-filled thyratron has a commutation factor rating of 200. Thus it can be used in motor control without the need for snubber circuits and without the occurrence of gas clean-up. (Commutation factor is the product of the rate of current decay in amperes-per-microsecond just prior to commutation and the rate of inverse voltage rise in volts per microsecond just after commutation.) Maximum ratings include: maximum peak anode voltage, 1,500 volts; maximum cathode current, peak 150 amperes, average, 12.5 amperes; maximum negative control-grid voltage, 250 volts before conduction and ten volts during conduction. Further information on the *GL-5855* may be obtained from the Tube Division, General Electric Company, Schenectady, N. Y.

Inputuner. The new Du Mont series *T3A* inputuner provides reception of frequency modulation as well as television channels by employing the Mallory-Ware

(*Continued on page 38A*)



Let's look at
LIGHTNING ARRESTER TOLERANCE
another way..

- You add it to average ratings
- But take it from Protective Margins
- Can you afford to waste any arrester protection?

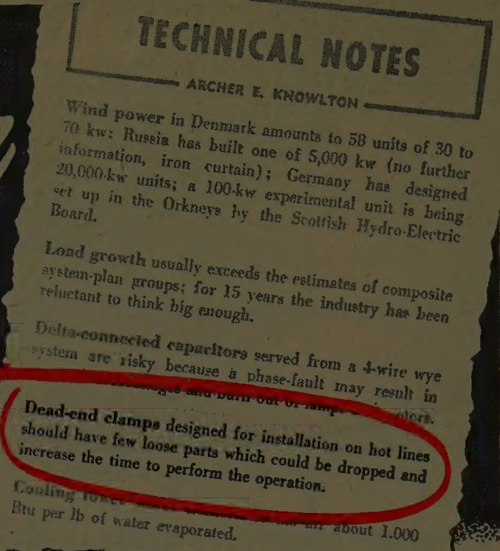
The story of lightning arrester tolerance is told in graphic terms in the accompanying curves relating to a typical 69-kv transformer. All published arrester values are *average* ratings to which tolerance is *added.* Between these basic *average* ratings and the demonstrated strength of the transformer exists a zone called the "Protective Margin". It's not so important that tolerance is added to published values as it is that tolerance is *deducted* from that vital Protective Margin. This is just a different way of saying the same thing--but an important difference! --And while you are considering tolerance, bear in mind that the O-B Thorex arrester has by far the closest tolerance ratings offered on the American market; giving you wider, more usable Protective Margins. Investigate this phase of the O-B Thorex.

Ohio Brass
MANSFIELD · OHIO

8115-H

We Agree with Mr. KNOWLTON

who made this statement in the November 6th 1950 issue of "Electrical World"



TECHNICAL NOTES

ARCHER E. KNOWLTON

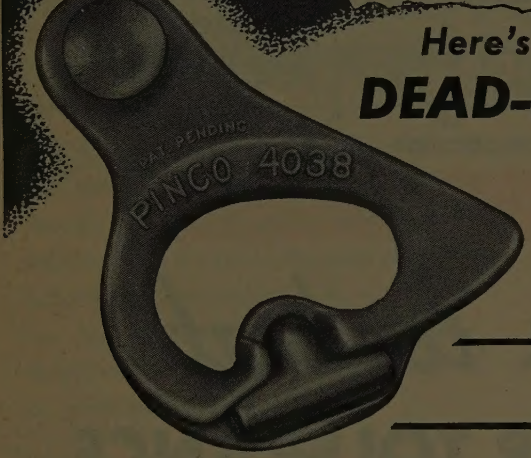
Wind power in Denmark amounts to 58 units of 30 to 70 kw; Russia has built one of 5,000 kw (no further information, iron curtain); Germany has designed 20,000-kw units; a 100-kw experimental unit is being set up in the Orkneys by the Scottish Hydro-Electric Board.

Load growth usually exceeds the estimates of composite system-plan groups; for 15 years the industry has been reluctant to think big enough.

Delta-connected capacitors served from a 4-wire wye system are risky because a phase-fault may result in [illegible] and burn-out of lamps [illegible] otors.

Dead-end clamps designed for installation on hot lines should have few loose parts which could be dropped and increase the time to perform the operation.

Cooling tow[illegible] about 1,000 Btu per lb of water evaporated.



Here's a DEAD-END CLAMP with NO LOOSE PARTS

If this is news to you, then it is our fault—because this Pinco L 4038 Dead-End Clamp was introduced eleven years ago! Prior to that time, all other clamps of this type had as many as *eight loose parts* which made them extremely difficult to assemble on the job.

The Pinco L 4038 Clamp with its simplified design not only speeds up installation but shows definite improved vibration characteristics with small copperweld or stranded copper conductors—(from .16″ to .375″ diameter inclusive). Today's model is even more efficient. An *extra long* J-Bolt Keeper of improved design *doubles* the clamping area on the conductor (contacts *all* wires in the long-lay conductors) . . . holds them securely without damage.

This Pinco L 4038 Clamp is another example of sound product planning which pays off in improved performance. Remember this whenever you specify and buy insulators and line hardware.

The Porcelain Insulator Corporation
763 Main St., Lima, N. Y.

Sales Agents: JOSLYN MFG. & SUPPLY CO.
Offices in Principal Cities

PINCO INSULATORS

Suspension Insulators . . . Switch and Bus Insulators . . . Distribution Clamps . . . Distribution Pin Types and Guy Strains . . . Transmission Line Fittings . . . Tree Insulators . . . Transformer and Circuit Breaker Bushings . . . One Piece and Multi-part High Voltage Pin Types . . . Suspension and Strain Clamps . . . Indoor Bus Support Porcelain . . . Lightning Arrester Porcelain.

(*Continued from page 32A*)

3-section spiral inductuner plus antenna tuning. It is designed to work into the intermediate-frequency system of television receivers using a separate sound intermediate frequency, and is available with variations in the mixer-plate network, making it adaptable without alteration to various types of separate sound intermediate-frequency receivers. Input impedance is 300 ohms. Inclusion of the sound trap with the tuner is optional as well as the choice of either 21.25 or 21.75 megacycles per second sound center intermediate frequency. The tuner comes complete with a *6BC5* radio-frequency tube and a *6J6* mixer-oscillator. Any further details may be obtained from Allen B. Du Mont Laboratories, Inc., 35 Market Street, East Paterson, N. J.

TRADE LITERATURE

Loss Prevention Bulletin. "Properties of Flammable Liquids, Gases, and Solids," bulletin number *36.10*, is a source book for fire prevention engineers, published by the Factory Mutual Engineering Division, 184 High Street, Boston 10, Mass. It is available upon request.

Characteristics of Television and Cathode-Ray Tubes. A new booklet, "Sylvania Television Picture Tubes and General Purpose Cathode Ray Tubes," contains characteristics of 194 cathode-ray tubes for television receivers, oscilloscope and radar applications. It is available from the Advertising Department, Sylvania Electric Products, Inc., Emporium, Pa.

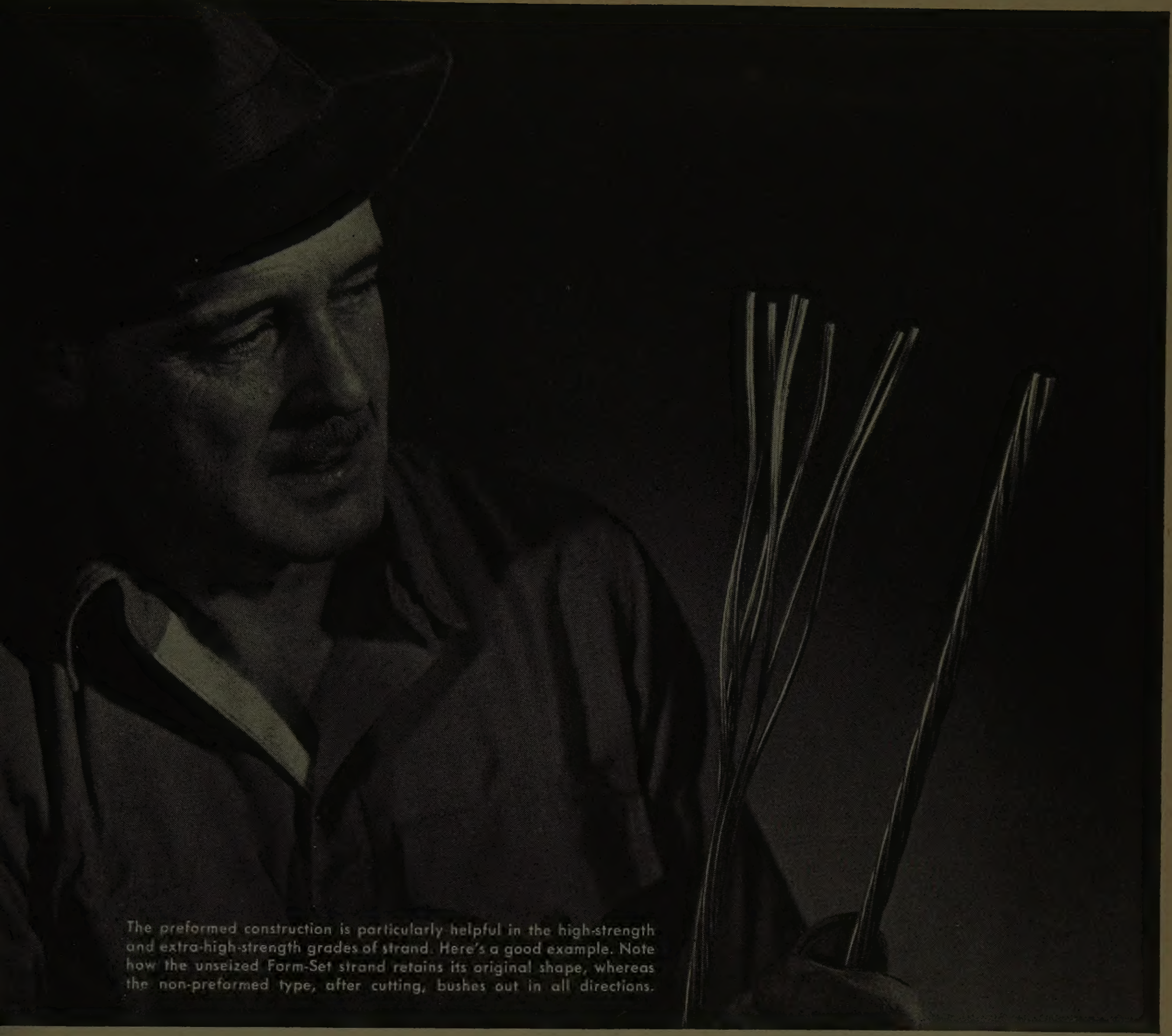
Measuring Dynamic Pressures. A newly developed measuring system for directly obtaining true dynamic pressure variations is described in a folder published by Electronic Associates, Ltd., 778G El Camino Real, San Carlos, Calif. Identified as form *SA5-950*, this publication contains a discussion of the problems involved in correcting conventional measurements for phase and amplitude errors inherent in tubing-connected pressure-sensing cells. Copies are available from the company.

Electronic Tube Engineering Manual. An engineering manual and catalog which covers the subject of gaseous discharge-rectifier and control-rectifier tubes, tube protection, efficiency, regulation, mechanical design and variations, has been issued by Electrons, Inc., 127 Sussex Avenue, Newark 4, N. J. It may be obtained from the company upon request.

Locknuts. "Types of Locknuts" and their principles of operation are illustrated and discussed in a new booklet which is available from the Locknut Section, Industrial Fasteners Institute, 3648 Euclid Avenue, Cleveland, Ohio.

Magnetic Amplifier Service Sheets. The Vickers Electric Division, Vickers, Inc., 1815 Locust Street, St. Louis 3, Mo., has issued a new set of service sheets for their

(*Continued on page 46A*)



The preformed construction is particularly helpful in the high-strength and extra-high-strength grades of strand. Here's a good example. Note how the unseized Form-Set strand retains its original shape, whereas the non-preformed type, after cutting, bushes out in all directions.

Vhy FORM-SET Strand is EASIER to handle

he basic reason, of course, is that Bethlehem Form-et strand is *preformed* strand; the wires, one by one, re relieved of internal tension before being laid ogether. This is accomplished by giving each wire ts permanent curl or shape before it goes into the trand with its neighbors.

Form-Set's reduced wire tension means several ractical advantages. The strand doesn't "explode" hen cut . . . it need not even be seized. Hence it lides quickly, smoothly, into the ends of fittings; ere's no lost time, no pinching together of stubborn ires. Matter of fact, in Form-Set, there isn't any tubbornness at all.

Expensive? Quite the reverse. Form-Set strand costs very little more than conventional, non-preformed types. The extra charge is so minor it hardly warrants talking about.

Order a reel of Form-Set; have your linemen try it. Then, just as a check, ask them how they like this strand. We think they'll confirm what we've told you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

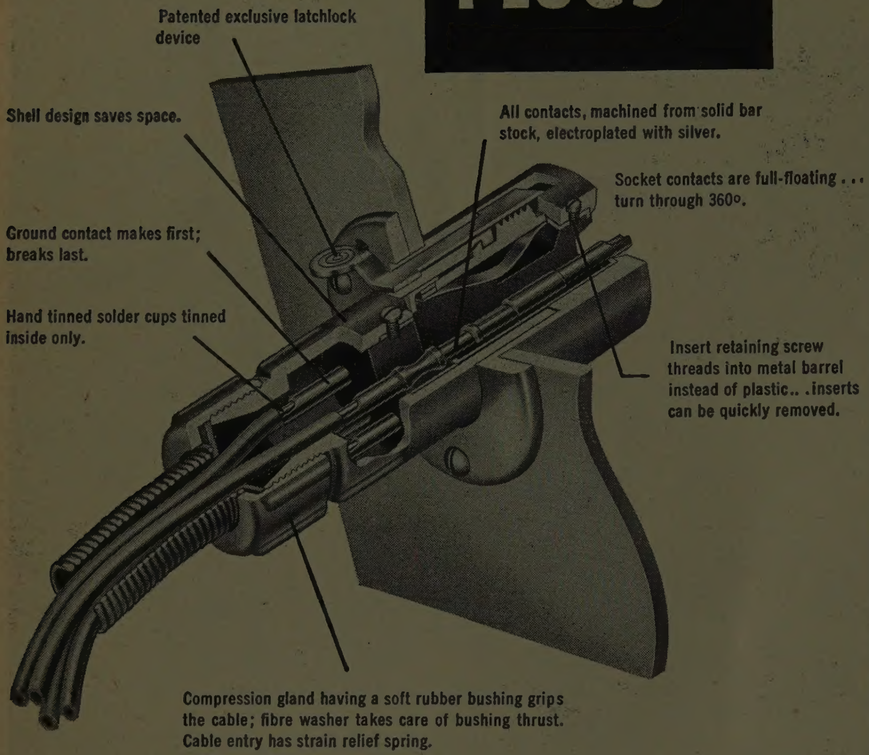
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM
STEEL

Here's why those in the know

–demand

CANNON PLUGS


Patented exclusive latchlock device
Shell design saves space.
All contacts, machined from solid bar stock, electroplated with silver.
Socket contacts are full-floating . . . turn through 360°.
Ground contact makes first; breaks last.
Hand tinned solder cups tinned inside only.
Insert retaining screw threads into metal barrel instead of plastic.. .inserts can be quickly removed.
Compression gland having a soft rubber bushing grips the cable; fibre washer takes care of bushing thrust. Cable entry has strain relief spring.

No corners are cut . . . nothing is overlooked to assure you outstanding performance with Cannon Plugs. So long an engineer's choice, the words "Cannon Plugs" have become part of our electrical language. Continued excellence of design . . . ability to meet your changing requirements . . . are good reasons why the Cannon line of connectors continues to excel where specifications must be met. XL Connector Series is just one of the many Cannon types—world's most complete line. Request bulletins by required type or describe your needs.

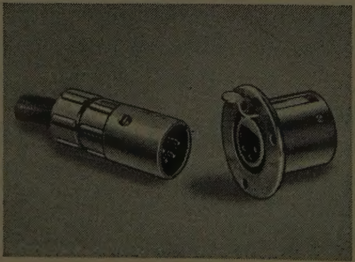
CANNON ELECTRIC

Since 1915

LOS ANGELES 31, CALIFORNIA

REPRESENTATIVES IN PRINCIPAL CITIES

In Canada & British Empire: Cannon Electric Co., Ltd., Toronto 13, Ontario. World Export (Excepting British Empire): Frazar & Hansen, 301 Clay St., San Francisco.



There are 12 items in the XL line. Insert arrangements available: 3—15 amp. contacts, 4—10 amp. contacts—working voltage 250 volts. Zinc and steel plugs with bright nickel finish are standard. Satin chrome finish also available on steel plugs.

(*Continued from page 38A*)

DH-2 handbook, containing a classification chart, *2600*, and bulletins *2201-08*; *2211-18*. These new service sheets may be obtained from the company upon request.

The Control Story. "The Control Story" briefly outlines types and applications of automatic controls in heating, ventilating, and air-conditioning systems for the architect and engineer who specify this equipment. Copies are available from the Barber-Colman Company, Rockford, Ill.

Motion Picture Camera Bulletin. The Flight Research Engineering Corporation, Post Office Box 1-F, Richmond 1, Va., has published a bulletin describing their new model IV 35-millimeter synchronous motion-picture camera. The bulletin is available from the company upon request.

Phono Accessories; Educational Equipment for Labs. The General Electric Company has made available two new booklets: a phono accessory catalog containing technical data on their variable reluctance cartridges, replacement baton styli, tone arms, and phono preamplifiers; and a 16-page bulletin on educational equipment for electrical laboratories. Designated as publication *GEA-5526*, this bulletin deals with rotating apparatus, loading devices, instruments, motor control equipment, distribution equipment, and dynamometers. The former bulletin is available from the Electronics Department, General Electric Company, Syracuse, N. Y., and the latter bulletin, *GEA-5526*, may be obtained from the company at Schenectady 5, N. Y.

Coil Spring Buyer's Guide. Intended primarily for the use of purchasing agents and coil spring buyers, the "Spring Buyer's Guide" published by the Hunter Spring Co., Lansdale, Pa., also is valuable to engineers and others who deal with springs, because it discusses the various factors affecting the cost of these springs. It is available upon request.

"The Tool for the Job." The Air Reduction Sales Company has completed a Kodachrome sound motion picture, which tells the story of the new Aircomatic process for welding aluminum, stainless steel, bronzes, and monel. Showing time for this 16-millimeter, 2-reel picture is 21 minutes. It was designed for showings to engineering meetings and technical society groups. For further details, and to make arrangements for the showing of "The Tool for the Job," contact Air Reduction, 60 East 42nd Street, New York 17, N. Y.

Wood and Fibre Wedge Information. The latest data on both wood and fibre wedges, which are used to hold windings in motor slots, reduce mechanical hum in transformers, and for other electrical purposes, has been made available by the Insulation Manufacturers Corporation, 565 West Washington Boulevard, Chicago 6, Ill.